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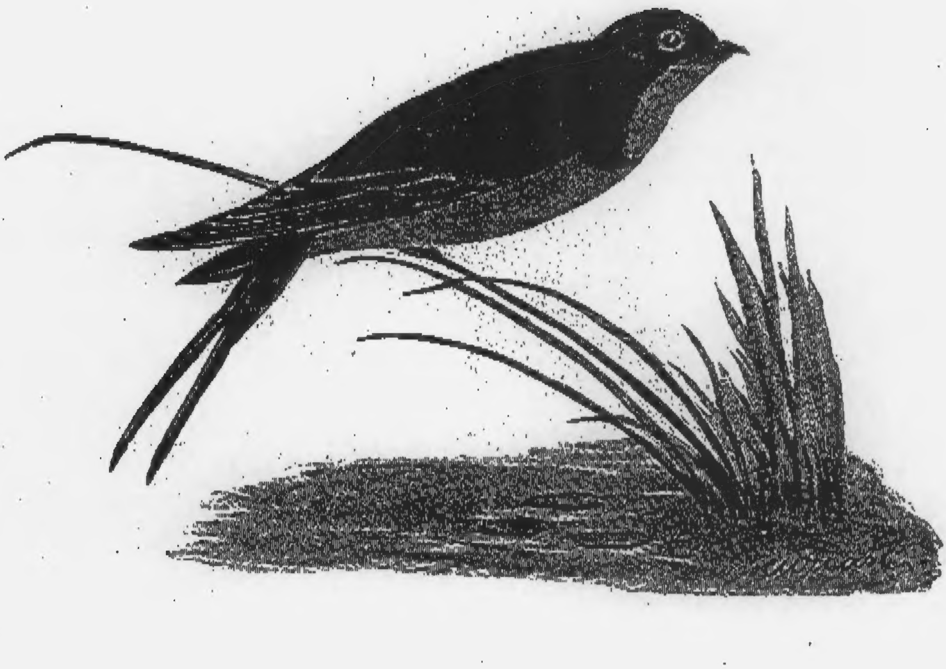

BARN SWALLOW
Chelidon erythrogaster

With kind regards from A. C. L. 5

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

REPORT

ON THE GEOLOGY

OF THE

LAKE OF THE WOODS REGION,

WITH SPECIAL REFERENCE TO THE KEEWATIN (HURONIAN ?) BELT OF THE ARCHÆAN ROCKS.

BY

ANDREW C. LAWSON, M.A.

PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1885.

To A. R. C. Selwyn, LL.D., F.R.S.

Director of the Geological and Natural History Survey of Canada.

Sir,—I herewith submit to you my report upon the physical and geological features, and economic resources of a portion of the Lake of the Woods region, together with a geological map of the same, on a scale of two miles to the inch, embracing an area of 72×48 miles. The preliminary portion of the work was done in 1883, in which year I was acting under instructions from Dr. Bell, as his assistant. In 1884 the bulk of the work was accomplished, but several weeks from the season of 1885 were required to complete it. To satisfactorily map the field geologically, it was found necessary to make a topographical survey, with micrometer and compass, of all the shores and islands of the Lake of the Woods within the limits of the accompanying sheet. This topographical work was by far the most laborious and time-consuming part of the survey, but has resulted in adding largely to our accurate knowledge of the region altogether apart from the geology, for the elucidation of which the new topography was necessary. I have confined my attention chiefly to the belt of schistose rocks hitherto regarded as of Huronian age, but the distribution of the surrounding Laurentian gneisses has also been determined.

Our grateful acknowledgments are due to Mr. Mather of the Keewatin Lumbering Co., for the loan of certain maps of local surveys, Mr. Matheson and other officers of the Hudson Bay Co., at Rat Portage, for much kind assistance, and to Mr. Dolmage, Mr. Oliver, Capt. Johnston, and Mr. Gibbons for various favours to myself and party.

I have the honor to be,

Sir,

Your obedient servant,

ANDREW C. LAWSON.

NOTE.—The bearings throughout this report are with reference to the true meridian, unless otherwise stated. The variation is 10° 30′ East.

REPORT

ON THE GEOLOGY

OF THE LAKE OF THE WOODS REGION.

WITH SPECIAL REFERENBE TO THE KEEWATIN (HURONIAN?) BELT OF THE ARCHÆAN ROCKS.

PRELIMINARY REMARKS.

In July, 1883, in accordance with instructions received from Dr. R. Bell, as whose assistant I was then acting, I proceeded to make, in conjunction with Mr. J. W. Tyrrell C. E., and assisted by Mr. F. Cochrane, a geological and topographical survey of the shores and islands of the northern portion of the Lake of the Woods and of Shoal Lake. The method of survey adopted was that whereby the distances are measured with a micrometer telescope in terms of a known base, and the bearings determined by the prismatic compass. The topographical work devolved upon, Mr. Tyrrell, who travelled in a canoe, while I and Mr. Cochrane used a large boat, in which was carried the greater part of our supplies and camp equipment. Mr. Cochrane attended to the management of the discs or base upon which Mr. Tyrrell sighted, while I gave my attention to the rocks, and also made a running compass-survey of the ground covered, as a check upon Mr. Tyrrell's work. About two months only were devoted to this work, and for the rest of the season Mr. Tyrrell and myself were engaged in exploratory examinations elsewhere, Mr. Tyrrell making a track-survey of the route from White-fish Bay to Deer Lake, and I an examination first of the shores the Lake of the Woods from the mouth of the Rainy River to Sabaskong Bay and of Sabaskong Bay itself, then of the chain of lakes between Big-stone Bay and Hawk Lake station, of which I also made a track-survey, and finally of Black Sturgeon Lake. In the short space of time allotted to the detailed work during the first part of the season, little more than a beginning could be expected in the survey of a lake of such tortuous shore-lines, and so full of islands as the Lake of the Woods. The main lines of survey were, however,

Work accomplished in 1883.

Methods of survey.

run and a rapid reconnaissance made of the leading geological features. In 1884, having been placed in charge of a party, in which J. W. Tyrrell and Mr. W. F. Ferrier were my assistants, with instructions to continue the survey of the previous season, I proceeded to Rat Portage and began work about the end of May. The work was carried on, both as regards the geology and the topography, in the same manner as before, excepting that I used another canoe to enable me to more closely examine the shores without delaying the topographical work, and that a Massey's patent boat-log was used in minor surveys, which could be checked by points fixed by more reliable means. Omitting White-fish Bay and the south side of the Grande Presqu'isle, nearly the whole of the shores of the lake, within the limits of the accompanying sheet, together with the contained islands of Shoal Lake, had by the close of the season been carefully examined and topographically surveyed with as much accuracy as the methods adopted would permit.

Progress of examination in 1884.

Fixed points.

For cartographical purposes, fixed points and lines such as the "North-west Angle" of the Lake of the Woods, the various township lines that have been run within the limits of the area, and the railway, served as excellent checks and corrections to the errors incident to a micrometer and compass survey.

In addition to the survey of the Lake of the Woods and Shoal Lake, a number of smaller excursions were undertaken, both with canoe and on foot beyond the basin of the lake, for the pupose of determining the position of various geological lines. And at the close of the season, toward the end of October, I made a hurried run from Turtle Portage to Fort Frances by way of the 'back route,' for the purpose of acquiring a general acquaintance with the Rainy Lake region, which it was proposed to place under survey the following season. While in the neighborhood of Fort Frances, I spent about three days in the excavation of two mounds of prehistoric origin, on the farm of Mr. McKinstry at the confluence of the Little American and Rainy Rivers. I was rewarded by finding a number of relics of bygone oboriginal workmanship, an account of which will be given elsewhere.

Completion of field work.

In 1885, I was instructed to complete the surveys necessary for the publication of the sheet which accompanies this report, and then to commence a similar geological and topographical survey of Rainy Lake. During the season my assistants were Messrs. A. E. Barlow, B.A., W. H. Smith. C.E., and C.S. Morton, B.E. The unfinished work requisite for the Lake of the Woods sheet comprised a survey of the shores and islands of White-fish Bay and a survey of the south side of the Grande Presqu' île and the off-lying islands. The former task

was successfully completed by Messrs. Barlow and Smith, who found the topographical features of the bay much more intricate than had been anticipated; while the latter was undertaken by myself and Mr. Morton.

Map.

The surveys of 1883 and 1884 were plotted and partially mapped by Mr. Tyrrell, who, however, left to take charge of one of the meteorological observatories on Hudson Street. After his departure, the work was continued by Mr. Barlow, upon whom the chief labor of the compilation of the present sheet has accordingly devolved, and to whom credit must be given for whatever excellence the map may possess in a cartographical point of view. Hitherto no systematic attempt has been made to completely map the Lake of the Woods. There have, however, been a number of partial surveys, the manuscripts and printed maps of which have been found of much service in a general compilation. The more important of these that have been made use of in conjunction with our own surveys are as follows:—Joint maps of the North American Boundary Commission published in 1878, which include a map of the North-west Angle Inlet; Russell's map of the Third Base-line as run through to the Iron Bar near Point Dispute with accompanying traverses; Kennedy's map of a group of islands between Yellow Girl Point and Monument Bay; Miles' map of Sabaskong Bay and the south side of the Grande Presqu' île; the Canadian Pacific railway surveys, and the Dominion Lands block outlines.

Previous surveys.

Previous geological examinations.

The geological work that has hitherto been done on the Lake of the Woods has, like the topographical, been of a rather fragmentary character; and no attempt to systematically study and map the geological relations and structure of the rocks exposed on all its shores and islands has previously been made. It may be well to note what has actually been done in this direction, and refer to the extant geological literature of this field. The following works are mentioned in order of their publication:—

Keating's expedition.

"Narrative of an expedition to the sources of St. Peter's River, Lake Winnipeek, Lake of the Woods, etc., performed in the year 1823, compiled from the notes of Major Long, Messrs. Say, Keating and Calhoun, by Wm. H. Keating, A.M., etc."

This gives observations for latitude on one or two islands that cannot now be identified accurately; notes the change in the aspect of the rocks in crossing the old Rat Portage near the present Keewatin station, and makes brief remarks upon the rocks at the few points at which the party stopped in its passage through the Lake.

Dr. J. J. Bigsby

Paper on the "Erratics of Canada" by J. J. Bigsby, M. D., Quarterly Journal of the Geological Society, Vol. VII. In this, the chief point made as regards the Lake of the Woods, is the fact of the limitation of

the limestone boulders to the south part of the lake, which the author explains by the supposition that this part of the lake is a limestone basin from which the limestone boulders were derived. He remarks in this connection: "The points to be noticed in the Lake of the Woods are—the abundance of primitive travelled blocks—their northern origin—the total absence of calcareous erratics in the north and the large sand-beds in the southern part of the lake." No observations on the direction of striæ are given.

Paper "On the Geology of the Lake of the Woods, South Hudson's Bay," by J. J. Bigsby, Quart. Jour. Geol. Soc., Vol. VIII, 1852.

In this paper, Dr. Bigsby mentions the various names applied at the time of his visit to different parts of the lake, as follows:—

Names of places.

"Lake of the Woods or Kamnitic Sakahagan."—This is more probably the Indian equivalent of "Island Lake" which was perhaps with more likelihood than "Lake of the Woods," the original Indian name, he present name having arisen by mistranslation.

"Clearwater Lake."—Probably a confusion with the north-west part of the lake known as Clearwater Bay, or with the present White-fish Bay which is still called by the Indians Clear-water.

"Lake of the Sand Hills or Pekwaonga Sakahagan."—From the sand dunes near the mouth of the Rainy River.

"Whitefish Lake or Whitefish Bay."—Only now applied by the Indians to the sheet of water east of the Sioux Narrows.

Geological maps

The paper is illustrated by a map of the lake upon which are represented the author's conceptions of the geology of the region Since, however, the paper was apparently based upon a limited number of observations and was published, as was also the former one, about twenty-five years after those observations were made, it does not afford us a remarkably clear comprehension of the features of the field. It has the credit, nevertheless, of being the first attempt at a geological description of the Lake of the Woods. As regards economic geology, it is stated that "In no part of the Lake of the Woods were any traces of metallic ores discovered, although carefully looked for."

Dr. D. D. Owen

"Report of a Geological Survey of Wisconsin, Iowa and Minnesota," by D. D. Owen, 1852.

The map accompanying this report shows the west side of the Lake of the Woods, from Rainy River to Winnipeg River, colored as a region of metamorphic and granitic rocks, although the explorations of the survey do not appear to have extended to the lake.

"Report on the country between Lake Superior and Lake Winnipeg, by Dr. Bell, in Report of Progress, Geological Survey of Canada, for 1872-3."

On page 104 and 105 of this report, Dr. R. Bell gives notes on the geology of the lake, based on observations made upon a trip from Rat Portage to the North-west Angle. The name Huronian is here first given to the schists of the Lake of the Woods. "The junction of the Laurentian rocks on the north with the Huronian schists of the Lake of the Woods on the south takes place at Rat Portage." And again "In going south-westward from Rat Portage to the entrance of the North-west angle of the Lake of the Woods, a distance of about forty miles, the rocks observed on all the islands consist of Huronian schists, with associated granites." The junction of Laurentian and Huronian is noted as conformable and the probable course of the line of junction, is sketched. A few detailed notes are also given of specific localities observed on the route through the lake. Examinations by Dr. Bell.

The following year, Dr. Bell had occasion to cross the lake from the mouth of Rainy River to the North-west Angle, and in his report for 1873, he devotes a paragraph to recording observations made on the route, the results are regarded as confirmatory of the views set forth in the reports of the previous year.

"Geology and Resources of the region in the vicinity of the Forty-ninth Parallel," by Dr. G. M. Dawson, 1875. Dr. G. M. Dawson's report.

In this work Dr. Dawson devotes a chapter to the geology of the Lake of the Woods, which is the fullest treatment that the subject had up to that time received. He describes in considerable detail the rocks met with along the canoe route from Rat Portage to the North-west Angle, and from that point to the mouth of the Rainy River, by way of the south side of the Grande Prisqu' îsle and Big Island; and gives a description of the shores of the lake on the United States side of the boundary. The intrusive granites in the vicinity of the mouths of the North-west Angle Inlet, are especially noted, and certain probable generalizations suggested as to their relations to the formations through which they break. The volcanic origin of a large part of the Huronian (Keewatin) rocks is also recognized. The glacial phenomena receive a large measure of attention, the direction of glacial striæ observed along his line of travel being accurately recorded, and interesting notes given on the aspect of the *roches moutonnées* and the character and distribution of the drift.

"On the geology of the Lake of the Woods and adjacent country, by Dr. Bell, in Report of Progress, Geological Survey of Canada, for 1880-82."

Dr. R. Bell gives in this report an account of the most recent work that had been done on the Lake of the Woods, prior to my own. He spent part of the season of 1881 in this region, and in his report for that year gives the results of observations made along the line of the Cana- Report by Dr. Bell.

dian Pacific railway, and in traverses around White-fish Bay, and across the Lake of the Woods, and Shoal Lake, together with other notes not applicable to the field to which the present report relates. The facts which had thus been ascertained by Dr. Bell, in the various explorations made in this county in this and previous seasons, enabled him to publish a preliminary "Geological Map of the Lake of the Woods and adjacent county," to accompany his report, showing approximately the relative distribution of the Laurentian and the "Huronian" rocks of the region.

REASONS FOR PROPOSING THE NAME 'KEEWATIN.'

Correspondence of Lake of Woods rocks with typical Huronian doubtful.

The belt of schistose rocks which runs through the granitoid gneiss, across the northern parts of the Lake of the Woods has, as above stated, been regarded as of Huronian age. In this report, upon the first detailed investigation of the belt as a whole, I feel it incumbent upon me, at the outset, to say a few words on the nomenclature of the series of rocks comprised within it, and particularly to question the advisability, in the light of recent investigations, of relegating these rocks to a position stratigraphically and geognostically equivalent to the typical Huronian of Sir William Logan, as described in the Geology of Canada, (1863). It must always be an extremely difficult matter to demonstrate the equivalency or non-equivalency of any two widely separated sets or series of Archæan rocks, devoid of fossils. Lithological similarity has by no means been established as a criterion of geological equivalence, except in a very general way, of little or no value in specific comparisons of given series of rocks. On the other hand, it seems reasonable to suppose, (and indeed the rocks themselves establish the fact), that volcanic activity played a much more important part in the development of the formations of Archæan times than in that of later geological ages; and farther, since these volcanic rocks were mixed with ordinary aqueous sediments, and the volcanic action was intermittent and irregular, we would expect to find series of the same geological age, of all gradations of lithological character, from an almost wholly volcanic to an almost wholly sedimentary composition. Thus the extreme dissimilarity of series so composed would be no proof of geological disparity. Lithological character is only one of several considerations that must be taken into account in a question of the corelation of two geological series geographically separated.

Lithological characters uncertain criteria.

Points of difference from typical Huronian.

The schistose belt of the Lake of the Woods appears to me to differ from the typical Huronian of Sir W. Logan, both lithologically and in other respects. The typical Huronian of Logan is, from his description

of it, essentially a quartzitic series, in which the quartzites are true indurated sandstones.* The schistose belt of the Lake of the Woods is not so characterized. Quartzites form an extremely small proportion of the rocks of the Lake of the Woods, and then they are only local developments in formations of mica-schist and felsite-schist. Bedded limestones are characteristic of Logan's typical series. On the Lake of the Woods there are, so far as I have been able to determine, no bedded limestones, the nearest approach to them being small segregated bands of dolomite, of the character of vein-stones. These two differences alone are sufficient to throw doubt on the equivalence of the two series, if lithological character is to be regarded as an aid to geological classification. There are, however, other differences. The basal conglomerate of Logan's Huronian, on Lake Temiscamang, is described as "holding pebbles and boulders, sometimes a foot in diameter, of the subjacent gneiss, from which they appear to be derived. The boulders display red orthoclase feldspar, translucent, colourless quartz, green hornblende and brownish-black mica, arranged in parallel layers, which have a direction according with the attitude in which the boulders were accidentally enclosed." The rocks on the Lake of the Woods, which are in the following pages referred to as "agglomerate-schists," are not basal conglomerates. They are not at the base of the series included in the schistose belt, nor are they apparently composed of water-worn fragments, derived from the rocks upon which they rest.

Quartzites unimportant.

No true basal conglomerate.

No fragments that can be referred to the underlying granitoid gneisses are found included in the agglomerate-schists of the Lake of the Woods. All the facts connected with them point to a volcanic origin for these agglomerates†, and the fragments are very frequently sharply angular, often with re-entering angles, although, for the most part they are elongated and lenticular in shape as a result of pressure, and the paste in which they are imbedded does not differ from them materially in composition as a rule. In rare instances they pass into pebble- or boulder-conglomerate, in which the pebbles are usually of a reddish felsitic material and indicate the co-existence of aqueous, with volcanic deposition.

Fragmental rocks of volcanic origin.

The "green slate rock" conglomerates at the mouth of the Doré River, Lake Superior, described by Sir W. Logan, supposed by him to

Resemblance to Doré River series and remarks on this.

* Preliminary Paper on an Investigation of the Archæan Formations of the North-Western States. by Roland D. Irving (Extract from Fifth Annual Report of U. S. Geological Survey,) pp. 230, 236.

† Dr. G. M. Dawson, speaking of these rocks says: "The conglomerate rocks have, as a whole, much the aspect of volcanic breccias, such as those found in association with the older Silurian series in Wales and Cumberland; and volcanic action would appear to offer the most reasonable explanation of their origin and distribution." Geol and Resources, Forty-ninth Parallel, p. 52.

be equivalent to the rocks of his main Huronian area, appear to resemble the agglomerate-schists of the Lake of the Woods. This Doré River area of "green slate rocks" is, however, geographically distinct, and appears to differ from the series in the typical Huronian region. The rocks are described as standing in a nearly vertical attitude, while those of the latter are comparatively flat. Neither are they associated with beds of quartzites or limestones to a material extent. Those differences, with the geographical separation, may, I believe, warrant us in considering the possibility of Logan having embraced under one designation two distinct series, and in regarding as Huronian, for the present, at least, only his main Huronian area, which is mapped in detail.

Basal rocks on Lake of the Woods.

As a general rule the basal member of the schistose series of the Lake of the Woods is a group of black hornblende-schists with associated trap-rocks, principally altered diabases and diorites. In Logan's Hurorian, this formation appears to be wanting in this stratigraphical position, or finds its analogue in "a mass of rather coarse-grained greenstone or diorite, usually interposed between the Laurentian gneiss and the recognized Huronian rocks, on the Sturgeon, Wahnapitae, and White-fish Rivers; but whether this is an overflow constituting the base of the upper formation, or an eruptive mass in the form of a dyke intruded at a later period, has not been ascertained."

Mica-schists, hydromica-schists and clay-slates appear to be but sparingly, or not at all represented in Logan's typical Huronian series. In the Lake of the Woods belt they are extensively developed and form an important constituent of the series.

Main point of resemblance to typical Huronian.

There is, however, one point of resemblance. In Logan's series there is 2,000 ft. of "chloritic and epidotic slate, interstratified with trap-like beds." In the Lake of the Woods belt, there is abundance of chlorite. The hornblende-schists, diabases and diorites are generally very much decomposed, and the rocks are as a result largely chloritic. In addition to this, there are formations—particularly interbedded with the hydromica-schists—of soft, finely fissile, green schists, which appear to be altogether chloritic.

In the face of so many important points of difference, I hesitate to believe in the equivalency of the two series, although quite prepared to admit the possibility of two series of geologically the same age having widely different lithological characters in geographically separate regions.

Period of flexure and granitic intrusion.

There are, moreover, other considerations. There are two conditions which appear to be generally characteristic of the Laurentian gneisses of North America:—1. They are sharply folded. 2. They are cut by intrusive granites. Now the Lake of the Woods belt of schists

is folded with the granitoid gneisses and is cut by several very large masses of granite and many smaller dykes. That is to say, the present schistose rocks of the Lake of the Woods were laid down upon the granitoid Laurentian gneisses, whatever may have been the original form of these, before the main era of folding was inaugurated and before the granites (probably as a concomitant of the folding) were forced up from below. It is extremely doubtful that this is true of Logan's Huronian series, from his description of it. The series is flat-lying or gently undulating, and its basal member contains "boulders of the subjacent gneiss, from which they appear to be principally derived."

Relation of granite intrusions to typical Huronian.

Further, Logan's mapped area of Huronian is not characterized by the presence of large masses of granite, although in the immediate vicinity of one part of this area "the intrusive granite occupies a considerable area on the coast of Lake Huron, south of Lake Pakowagaming. It there breaks through and disturbs the gneiss of the Laurentian series, and forms a nucleus from which emanates a complexity of dykes, proceeding to considerable distances. As dykes of a similar character are met with intersecting the rocks of the Huronian series, the nucleus in question is supposed to be of the Huronian age, as well as the greenstone dykes which are intersected by it." * Similarly, just beyond the northern border of Logan's Huronian area, "cliffs of syenite and granite" are recorded as observed on the Mississague River, although none are stated to cut the Huronian strata in the neighborhood. Logan does not state in so many words that the underlying gneisses are folded, but both on his map, by the plotted dips, and in his sections 1 and 1 A,† he shows that such he conceived to be their condition.

Points of difference.

It thus appears that while the Lake of the Woods schists are older than the time of folding and older than the granites which are intruded through them, Logan's typical Huronian has come into existence later than the time of folding of the gneiss and possibly also later than the main period of granitic irruption. If then we suppose, as there is every reason for doing, that the time of folding of gneiss and irruption of the granite was in a general way the same over this portion of the continent, we have the Huronian series and the Lake of the Woods series at once relegated to two very distinct geological ages.

Views of Prof. R. D. Irving.

The investigations of Prof. R. D. Irving, of the United States Geological Survey, have a further direct bearing on the question and afford an approximation to direct stratigraphical evidence. One result of his labors, which have extended over several years, is the con-

* Geology of Canada, p. 58.

† Atlas, 1865.

clusion which he has arrived at that the Animikie series of Thunder Bay is identical, lithologically and stratigraphically, with Logan's typical Huronian. He establishes the lithological similarity of the two series; points to the fact that both series are comparatively flat-lying and demonstrates the relations of each to gently folded or undulating series of rocks of similar lithological character, viz: the Marquette, Menominie and Penokee-Gogebic series, on the south side of Lake Superior, to which they appear to be equivalent, and which constitute a geographical chain of connection between them. If, then, the Animikie and Huronian are identical, as Logan himself believed as regards a portion at least of the Animikie, what are the relations of the folded schists of the Lake of the Woods to that flat lying series. This is a question still to be answered. Prof. Irving has expressed the opinion "that both the flat lying Animikie slates and the more northern folded iron-bearing schists are Huronian," and gives a diagram to shew the hypothetical identity of the folded and unfolded series on either side of the Mesabic range of granite and gneiss.*

These rocks do not represent the Animikie.

The folded schists to the north-west, however, so far as the Lake of the Woods series teaches, are as different from the Animikie as they appear to be from the typical Huronian, and were probably folded with the gneisses before the Animikie rocks existed as such. The Animikie series rests apparently on granite along part of its western confines. The granite of the region appears, as is known to have been the case in the Lake of the Woods, and has more recently determined to be true also for Rainy Lake, to be of later origin than the folded schists. Hence, in the superposition of the Animikie rocks upon the granite, we have again a sharp distinction in geological time between the Animikie (Huronian?) and the folded schists to the west, as represented by the Lake of the Woods series.

"So-called Huronian."

In the "Geology and Resources of the Forty-ninth parallel," Dr. G. M. Dawson refers (p. 50) to the Lake of the Woods rocks as "so-called Huronian," and points out (p. 52) their resemblance, first to the Hastings series (then described as Laurentian) and second to the rocks of the Quebec Group, at the time supposed to be much newer than the Huronian.

The name Keewatin proposed.

In view of the above facts, it seems expedient that this series of rocks should receive a convenient name, which shall be noncommittal as to geological relations, and which may be used provisionally till such time as those relations are established beyond question. The most appropriate name for the series that suggests itself to me is "Keewatin," the Indian name for the North-

* Third annual report U. S. Geol. Survey, pp. 170-171

west, or the North-west wind, which has been applied to the district within which the rocks occur. If the series should in future be definitely correlated with the Huronian of Logan,—or any other known and described series,—the name can be dropped, while, should it prove of permanent utility for purposes of geological classification, it may be retained.

The rocks so designated on the Lake of the Woods may be taken as representative of an important division of the Archæan, extensively developed in parts of the great Laurentian area, but here first investigated in detail.

RELATION OF PHYSICAL FEATURES TO GEOLOGICAL CONDITIONS.

Two parts of the lake.

The Lake of the Woods is naturally divided into two distinct parts, having strongly marked differences in their physical aspects. These may be referred to as the northern and southern portions of the lake. The northern portion has an excessively irregular, rocky coast-line, and its whole expanse is thickly studded with islands, varying in size from mere rocky islets to masses of land many miles in extent. The southern portion presents the contrasting character of a broad sheet of shallow water, almost totally free from islands, contained by low, sandy or marshy shores of gently sinuous outline, in which rock exposures are extremely few, the whole in remarkable opposition to the jagged cliffs and tortuous island-blocked channels of the northern portion.

Line of demarkation.

The line of demarkation between these two naturally distinct portions of the lake is nearly coincident with the international boundary line from the North-west Angle to the mouth of the Rainy River, were that line to bend round so as to pass the southern extremity of Bigsby Island and strike the main shore at the mouth of Little Grassy River, it would separate as nearly as possible the two portions of the lake thus characterized.

The northern portion of the lake occupies a short, broad belt of green, schistose Archæan rocks which have hitherto been referred to as Huronian. The southern portion appears to be wholly in a basin of Laurentian gneiss, the flanks of which pass beneath the drift on the Minnesota shores to the south and west.

In the northern portion of the lake, sand-bars and deposits of the finer kinds of drift are in general rare. In the southern, sandy beaches characterize the coast, and in the neighborhood of the mouth of the Rainy River, extensive spits or bars of sand have accumulated for many miles, upon which the wind has blown the loose dry sand into conical dunes, which seem at a distance to have a picturesque resemblance to a collec-

tion of Indian wigwams, and have given rise to the name of "The Lake of the Sand Hills" which is sometimes applied to this portion of the lake.

Drainage area. The lake forms a basin or reservoir for a drainage area of 36,000 square miles, half of which is on the Canadian side of the boundary. A considerable proportion of the water from this area drops in from small streams draining lakes near to the main lake, but by far the greater part finds its way to the lake by the Rainy River, the embouchure of which is at the extreme south-east of the lake. The waters of the lake are poured into the Winnipeg River, over the two beautiful falls on either side of Tunnel Island, near Rat Portage, at the extreme north end of the Lake. Both of these falls, the more easterly of which, from its beauty, may be called "Hebe's Fall," and the other the "Witch's Cauldron,"* present magnificent opportunities for the utilization of an inexhaustible motor power. In several parts of the lake there is a strong northerly current which gives it in these places the character of a river.

Outlet.

Limits of map. The greater part of the northern portion of the lake is included in the sheet accompanying the present report. The limits of the sheet are latitudes 49° 11′, and 49° 53′ north, and longitudes 94° and 95° 35′ west.

Main topographical features. In the details of topographical outline, the map will speak best for itself, but there are certain broad features which it may be well to notice. In shape, its apparently incomprehensible irregularity of outline is seen to conform to a certain systemmatic constriction or pinching off of the lake into different parts, by opposing peninsulas and belts of large islands. The most prominent of this series of constrictions is that which divides the lake about its middle by means of the Grande Presqu'île and the island at its western extremity, stretching from Turtle Portage on the east to the mouths of the North-west Angle Inlet on the west. This great dividing mass of land appears to be the flat truncated remains of an immense anticlinal dome, the nature of which is described in another portion of this report. The portion of the lake to the north of Grand Presqu'île is again medially constricted, the space between the Eastern Peninsula on one side of the lake, and the Western Peninsula at Crow Rock on the other, being only seven and a half miles in width. This space is almost completely blocked by a belt of four large islands, trending east-and-west, in a curve concave to the south, with very narrow intervening channels. This also is due to a

Constrictions.

* Neither of these falls had as yet received a name, and both are usually referred to as the "Falls," so that considerable confusion exists as to which is meant. Rat Portage and the Lake of the Woods are becoming a summer resort of some importance, and it seems not inappropriate that the names of the natural features should be in keeping with the picturesque and romantic character which makes them so attractive. It is for this reason that I propose the somewhat fanciful names which appear in this text, trusting that they will be acceptable to my friends, the people of Rat Portage.

comparatively well defined anticlinal structure in the strata, in the denuded and worn hollows of which, the lake lies. The repetition of this process of subdivision is seen in the northern of the two bodies of water thus formed, in Pipe-stone Point, and a similar belt of islands comprising Hay, Middle and Scotty Islands, stretching from the east side of the lake to within a mile and a-half of the peninsula—an island at high water—on the west side, terminating in Point Aylmer. This also presents the characters of an anticlinal ridge. The same thing is repeated in the belt of islands between the Devil's Gap and Dispute Point, although the relations of topographical contour to geological condition is not so apparent.

Four dividing ridges.

Thus viewing the lake in its general aspects, there is seen to be a four-fold repetition of these dividing ridges or belts of land, corresponding to as many great folds in the original strata of the region, which, most largely developed to the south in the Grande Presqu'île, have left, as their denuded and truncated remains, these ridges, diminishing regularly towards the north, and cutting off sections of the lake successively smaller.

To the south of the Grande Presqu'île, Pork Point, on the east side of the lake, and Driftwood Point on the west, with Bigsby, Big, Confield and other islands between, seem to constitute another belt, similar in character to those described to the north, and may be regarded as part of the same system of anticlinal, water-dividing ridges, although not embraced within the limits of the accompanying map.

White-fish Bay.

Two important portions of the Lake of the Woods yet remain to be noticed. These are White-fish Bay to the east and Ptarmigan Bay to the North-west of the main body of the lake. The former of these is a large body of water, closely packed with islands and almost entirely cut off from the rest of the lake by the Grande Presqu'île. The only connecting channel is the narrow passage, less than a quarter of a mile wide, situated about six miles south-east of Yellow Girl Point. With the exception of its extreme north and south ends, it lies entirely in Laurentian gneisses. It occupies the hollows of the eastern flanks of the anticlinal dome of the Grande Presqu'île, and, as a glance at the map will shew, conforms closely in the general trend of its shores, with the curvilinear disposition of the strata.

Ptarmigan Bay.

Ptarmigan Bay is also pinched off from the main body of the lake and is connected with it by an almost equally narrow passage, formed by the approach of the extremities of the Western and Southern peninsulas. Zig-zag Point and Cork-screw Island serve to separate Ptarmigan Bay proper, from a northern portion called Clear-water Bay.

Enclosed within the limits of the accompanying sheet is Shoal Lake, an extensive body of water, on a slightly higher level than the Lake of

the Woods, and separated from it by the Western Peninsula. It drains directly into Ptarmigan Bay, without the intervention of a river, by Ash Rapids, the name given to two small *chutes*, half a mile apart, with a little lake between. The difference of level between the two lakes varies with the abundance of water in different seasons. When the water is high, the lower rapid becomes obliterated, and it is possible to paddle over what at low water is a distinct fall of several feet. The level of Shoal Lake is much more constant than that of the Lake of the Woods, which has a rise and fall through a range of ten feet.

Shoal Lake.

Shoal Lake, though not resembling the Lake of the Woods in shape, has this feature in common with it, that while the northern end of the lake is thickly studded with islands, the southern portion presents an open 'traverse,' comparatively free from them, and also, that whereas the shores of the north are bold and rocky, towards the opposite end of the lake, they are low-lying, and at the extreme south quite sandy, with almost no rock exposures. It is a triangular-shaped lake, with apex to the south, and a long, irregular, island-fringed east-and-west-trending shore for base to the north. Its greatest north-and-south extent is thirteen and a-half miles, and its greatest breadth seventeen miles.

Outline dependent on geological features.

From the foregoing remarks, it will have been gathered that in the general features, the shape of the Lake of the Woods is dependent upon geological conditions. If we prosecute still further the investigation of this relationship, we shall find a surprisingly intimate connection, even in the details of the distribution of land and water. The dependence of the physical features of the earth's surface upon geological conditions becomes more or less apparent in all regions, when carefully studied, but nowhere could a better illustration of so interesting a truth be found than on the Lake of the Woods. The conditions which obtain in the rocks of the region, and which have had the most active influence in determining the aspect of its geographical features, are those of cleavage, relative hardness and mineral composition, and strike and dip. The strike and dip of the strata control more particularly the direction in which the forces of erosion operate, while cleavage, relative hardness and composition control rather the measure of rapidity with which these forces may act in the directions determined. These general conclusions, which may be regarded as an imperfect formulation of the law of erosion in these Archæan rocks, and which are based on a large number of observations in the field, may be illustrated by a few of the more striking instances that have been worked out.

Basin excavated in the schistose rocks.

If we consider first the relations of that portion of the Lake of the Woods to the north of the North-west Angle and Falcon Island, including Shoal Lake as part of the same eroded basin, to the rock formations

of the region, we shall be struck with the fidelity with which the confines of the lake adhere to those which limit the distribution of the Keewatin rocks. The hard, massive, granitoid gneisses of the Laurentian seem to have constituted a firmer and more resistant girdle to the area of softer, schistose rocks of the Keewatin within which a more rapid erosion has worn out the irregular-looking basin which contains the waters of the present lake. It is a remarkable fact, however, that, although the outlines of the basin of the lake are evidently determined by the *locus* of the contact of the Laurentian gneiss and Keewatin schists, the gneiss itself rarely constitutes the rock of the shore-line, but is generally faced, so to speak, with the schistose rocks, as if the backing of gneiss lent sufficient stability to the adjoining schists to resist the erosion that has eaten more deeply into them in the central portions of their area.

Gneisses support the softer rocks.

The only places where the gneiss appears at the edge of the water of the portion of the lake-basin under consideration, are on the west side of Shoal Lake, where the shore-line crosses the strike of the rocks, instead of running parallel to it, as is usually the case; on the south-east side of Shoal Lake, where the gneiss seems to come to the surface in the axis of an anticlinal fold; in Clear-water Bay, where there is an unusual break in the continuity of the strike of the rocks; and at the extreme end of Big-stone Bay.

The larger massses of intrusive granite exhibit apparently the same tendency to remain encased in a margin or border of the schists through which they have been protruded, and although these massive granites seem to be more readily susceptible of erosion than the laminated gneisses, they still appear to occupy the central or nuclear portions of the masses of land in which the are found. Thus the Canoe Lake granitic mass occupies the central portion of the large peninsula which separates Shoal Lake from Ptarmigan Bay, and is almost entirely surrounded by schistose, hornblende-rocks, diorites and diabases, which form the shores of the lake. The Yellow Girl granitic mass occupies the central portion of the Eastern peninsula and is similarly surrounded by schists, the strike of which, bending around the central intrusion, has given direction to the three sides of the peninsula. The granitic masses of Portage and Carl Bays, lie in about the centre of the Western Peninsula, although here the shore-line is deeply and irregularly indented into the heart of the granite areas on both sides.

Registence of various rocks to erosion.

The idea that the superior resistence to erosion exhibited by the rocks which lie between the shore-line and the gneiss which surrounds the lake basin, as well as the more prominent granitic areas, is in some way due to the proximity of these rocks to the gneiss or granite, is the one that first naturally suggests itself. This, in a measure, seems to be

true, although it is not the full explanation of the facts. The hornblende-rocks in contact both with the granites and granitoid gneisses, seem to be harder, tougher, blacker in color, and of a more freshly crystalline aspect than those at a distance from such contact. And it is altogether probable that these schistose hornblende-rocks have derived this extra hardness and toughness from the adjoining granites and gneisses, particularly since, as I shall endeavor to show elsewhere, the gneiss behaves, in its relations to the rocks with which it is in contact, exactly as intrusive granites do. But while these facts are to be considered in an estimation of the causes that have influenced the measure of erosion, it is to the mineralogical character of the rocks and their consequent relative hardness, independent of superinduced effects, that we must look for the more comprehensive explanation of the features of erosion. The difference in composition and hardness of the rocks in different portions of the lake is quite marked. The soft, fissile hydromica and diloritic schists are at one end of the scale, and the hard, black, schistose, hornblende-rocks, and massive basic rocks at the other, with mica-schists and agglomerates intermediate. The hornblende-schists, occupying for the most part the borders of the Keewatin area, and of the lake-basin, have been less liable to disintegration, *per se*, altogether apart from the fact of the contact with the gneiss or granite, while the hydromica-, chlorite-, agglomerate- and mica-schists, occupying more extensively the central portions of the area, have more easily yielded to these forces decomposition and disintegration which have worn out the hollows in which the lake lies.

Strike in relation to shore-lines.

The influence of strike in determining the direction of shore-lines, is however, the most notable feature in the relationship of geography to geology. Nearly all the rocks of the region are tilted at high angles, and the shore-lines of all parts of the lake, with few exceptions, tend to coincide with the trend of the strike. If the rocks dip away from the water inland, so that the cliffs have an overhanging aspect, the coarse disintegration of the rock proceeds more rapidly than when the dip is toward the water, and presenting a sloped face, which is much stabler as a barrier against the disintegration ting influence of wave and weather. But in either case, the line which in general limits the extent of the erosion and gives shape to the shore, is the line of strike. A few instances, illustrative of the close dependence of the direction of shores upon the trend of the rocks are given as follows:—

List of Coincidences of Shores with the Strike of the Rocks.

General axis of Pipe-stone Point	S 81° E.
Average strike of schists (25 observations)	S 80° 48′ E.
General bearing of shore from Rat Portage to west of Keewatin.	N. 74° E.
Average strike of schists (7 observations)	N. 74° 18′ E.
General axis of Indian Bay	N. 51° E.
Average strike of schists (9 observations)	N. 49″ 36′ E.
General bearing of shore, Point Aylmer to Ptarmigan Bay	N. 65° E.
Average strike of schists (17 observations)	N. 61° 6′ E.
General axis of Heenan Point and Needle Point	N. 22° E.
Average strike of schists (4 observations)	N. 21° E.
General bearing of north shore of Grande Presqu'île	N. 83° E.
Average strike of schists (16 observations)	N. 71° 48′ E.
General axis of Clear-water Bay	N. 86° E.
Average strike of schists (17 observations)	N. 81° E.
General axis of Ptarmigan Bay	N. 85° E.
Average strike of schists (28 obsverations)	N. 82° 12′ E.
General axis of Indian Bay, Shoal Lake	N. 72° E.
Average strike of schists (10 observations)	N. 75° E.

Shore-lines of Eastern Peninsula.

But the most remarkable instance of the dependence of shore outline upon the strike of the strata is that afforded by the Eastern Peninsula. This is a large, thick, three-sided mass of land, about nine miles long, projecting into the lake from the east side. Its central portion is occupied by a large mass of intrusive granite, which, breaking through the schists, has upheaved them and caused them to strike around the central mass in directions which seem to be the three sides of a rhomboid, the area of upheaval being coincident with the short diagonal of the rhomboid. In close correspondence with these trends in the strike of the strata are the shore-lines which define the shape of the peninsula. This will be seen, as before, by taking, as nearly can be judged, the general bearings of the shores and comparing them with average of the observed strike of the rocks exposed along them.

General bearing of north shore of Eastern Peninsula	S. 83° E.
Average strike of schists (12 observations)	S. 82° 30′ E.
General bearing of S. W. shore of Eastern Peninsula	N. 66° W.
Average strike of schists (9 observations)	N. 75° W.
General bearing of south shore of Eastern Peninsula	N. 83° E.
Average strike of schists (5 observations)	N. 81° E.

There are but a few of the many instances that might be adduced. Nearly all the minor points and bays of the lake which occur within the Keewatin area, have their shape determined more or less closely by the strike of the rocks, modified, of course, materially when there occurs a change in the character of the rocks, as, for instance, when a schist gives place to a hard massive diorite or diabase.

Denudation.

Denuding agencies.

The forces of erosion, however, concerned in the sculpture of this lake-basin, have by no means been simply those of ordinary shore disintegration. The lake, as such, is probably, of post-glacial origin, and the disintegration that has been affected since the basin it now occupies became flooded, is a very small fraction of the immense denudation that took place prior to, and by means of, the glaciers. In fact, the denudation of the region may, for convenience, be briefly considered under these three heads, which are in order, both of time and relative importance, viz:—

1. The denudation which preceded the glacial epoch.
2. The denudation affected by the action of glaciers.
3. The disintegration of the rocks since the glacial epoch.

Pre-glacial Denudation.

Rock decay and removal.

The first of these comprised two sets of forces, (1) those of rock decay and comminution, both chemical and mechanical, but chiefly chemical, and (2) those engaged in the removal of the debris to lower levels, also both chemical and mechanical, but chiefly mechanical. As regards the latter, the forces of removal, the conditions which obtain throughout the region point to their having been very moderate in intensity and gradual in their operation. The whole region, although extremely hummocky or mammilated in its surface aspects, presents extraordinarily little variation in level. There are no great valleys or high hills. The whole country is practically a plateau of very moderate elevation above the sea for so inland a region. In alluvial regions a comparatively rapid removal of surface material may take place without sharp contrasts of level existing, but in regions such as western Algoma*, where the surface is, and probably has been for ages, rocky

* The name of an electoral district, embracing the western part of Ontario as far as the boundary of the Province of Manitoba, which may be conveniently used in referring to the country west of Lake Superior, within the Province of Ontario.

denudation is, in the nature of things, much slower and more moderate in its action when that region is flat, than when it is mountainous. There is no evidence that the Archæan rocks of this district have at any period of their history been thrown into what may be truly called mountains, in contrast to the general level of the crust at the time when all these rocks were folded. The mountains of the globe, with which we are familar, appear to be, for the most part, simply linearly arranged areas of abnormally thick strata, deeply carved by a process of excessively active denudation. The plication of the earth's crust in itself has never been demonstrated to produce mountains independent of conditions of excessive accumulation of strata. The Archæan rocks of western Algoma are intensely plicated, yet that fact does not warrant us in assigning a once mountainous character to the region. Rapid denudation in rocky regions is characterized by high altitudes and deep gorges, partly as a cause and partly as an effect of such denudation. The wearing down of mountain ridges to the generally uniform level of the Algoma plateau, would certainly have been attended by the erosion of immense valleys and gorges, corresponding in their dimensions to the altitude of the mountains for whose debris they would have constituted the channels of removal. There are no great valleys or ravines cutting out this plateau. It may have been a plateau since Archæan times, probably of much more uneven surface than it now presents, but always of a generally uniform level. The southern flanks of this great Archæan plateau, in its extension east and west from the particular portion under consideration, appear to have been in much the same flat condition, as at present when the Animikie and Copper-bearing rocks of Lake Superior, and the Cambro-Silurian rocks of Manitoba and eastern Ontario, were laid upon them in the earlier geological periods.

District probably never a mountainous one.

But denudation implies rather the stripping off or removal of the loose material that has been reduced to a state of comminution by the agency of rock decay and disintegration. Of course, the less active the agencies of removal, the less often is fresh material exposed at the surface to the attacks of eroding forces. Rock decay, however, is not altogether confined to the surface, although disintegration is. Dr. T. Sterry Hunt has pointed out the probability that all the rocks of our Archæan regions were, in times prior to the glacial epoch, decomposed and soft to a considerable depth. In the same connection he advances the view, that a large proportion of our glacial erratics are simply the undecomposed nodules that have been left unaffected by this decomposition. Some facts that I have been able to observe on the Lake of the Woods, which lend support to these views, may be worth recording. The granitoid gneiss is not infrequently found to be remarkably decomposed or 'rotten' in areas of limited extent which appear to

Process of rock decay.

Instances.

have an approximately vertical attitude. In these areas, the same rock which a few yards away seems quite hard and fresh, is so soft and decomposed that it may be broken off by the hand, and crumbled between the fingers like a piece of loaf sugar. Two localities where this is most characteristically seen are on the west side of Falcon Island and on the west shore of the Grande Presqu'île. At both places, the shore presents a cliff of gneiss in which a vertical belt of rotten, friable rock, about a dozen yards or so in width, runs through the hard gneiss. The gneiss is coarse-textured with large porphyritic crystals of orthoclase and in the decomposed portion presents a rusty yellow appearance. The weakness of the rock appears to lie in the almost total lack of coherence between the quartz and mica. There is a considerable proportion of pyrites in the gneiss, but not more than is often found in such rocks when quite fresh. It is easy to conceive this rotten friable character of the rock to have once been much more prevalent, and that these downward-running belts of incoherent material may be but a survival or rudimentary stage of what was an almost universal condition of the surface of the Archæan rocks, before the glaciers came and scraped them clear to the hard and comparatively firm portions, upon which we now find engraved the glacial grooves and striæ.

Hard kernels in gneissic rocks.

On a small island south of Flag Island Point, the granitoidg neiss has the appearance of having enclosed within it rounded boulders of granite such as are shown in the annexed diagram. (Fig. 1.)

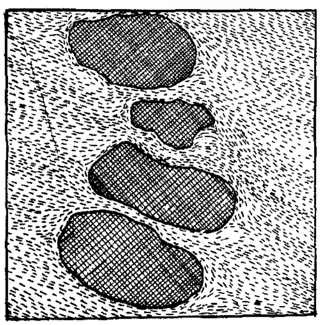

FIG. 1.—HARD KERNELS IN GRANITOID GNEISS.

The gneiss of the island, though quite granitoid, has still a perceptible lamination, the strike of which may be observed with little difficulty on a large surface although hard to discern in a hand specimen. The gneiss is much decomposed and has a bleached or yellow aspect, but is not noticeably soft or friable. The apparently included boulders were found on inspection, though seemingly different, to be the same

as the rest of the rock of the island, so far as composition and texture are concerned They were not, however, bleached, but had a fresh purplish-red hue, and were evidently much harder than the surrounding rock, from the fact that they weather out with a well rounded shape above the encircling, saucer-like hollows that have been worn out around them. The laminated structure is almost totally absent in these pseudo-boulders, as if that lamination were in some way a function of the decomposition of the rock. The lamination of the gneiss, exhibits a tendency to curve around these harder, ball-like portions. The line of demarcation between the gneiss and these boulders, which are doubtless undecayed nuclei of the same material, is rather a sharp one, but is not without evidences of transition. Around one of them there is a border half an inch wide, of a brownish color, intermediate between the purplish-red of the nucleus and the bleached yellow of the enclosing rock, which seems to mark the mergence from one to the other; and in the others, the line is not sharper than that found in many of the granitic rocks of the region dividing the two or three inches of bleached kaolinized surface rock from the fresh, bright-colored portions that have not been as yet perceptibly changed. These nuclei of hard rock in the midst of the gneiss are very suggestive of the origin of many of the rounded boulders.

Glacial Denudation.

Glacial denudation not profound.

The evidences of glacial action, so abundant in all parts of the lake, will be dealt with in another part of this report, but a few words may be said here about its erosive effect. The Lake of the Woods and surrounding country may be considered essentially as a partially flooded area of *roches moutonnées*. The whole country has been scraped bare, polished and grooved. But this scraping and polishing process seems to have done little more than expose the natural surface of comparatively undecomposed rock, upon which had previously rested, *in situ*, the upper decomposed soft portion. The curving of well defined grooves around sharp angles of solid rock, their passage over rock-surfaces presenting marked unevenness, due to jointing, and their bending under overhanging cliffs of massive rock, seem to leave little room for the belief that glacier ice had the power of rending solid rocks and carrying them off in fragments. Its action was confined to the removal, first of the loose earthy material, the result of rock decay, then by a process of attrition or grinding of the less decomposed but still soft lower portions, till the level of the present *roches moutonnées* were reached, presenting a surface sufficiently hard to be

Causes producing *roches moutonnées.*

grooved and polished. Thus the *roches moutonnées,* although they may be said to be the immediate result of glacial action, have their more remote and truer cause in the process of rock decay, the present mammilated surface of the country being simply the limit to which decay had so affected the rocks as to render them removable by glacier ice. The fact that the phenomenon of *roches moutonnées* is confined to regions of crystalline or Archæan rocks and not displayed in ordinary unaltered sedimentary rocks, even though profoundly glaciated, is strong presumptive evidence in support of the phenomenon being regarded as dependent, rather upon the character of the rock and the forces at work in it, than the result of any incomprehensible peculiarity in the action of the ice. The Cambro-Silurian and later sedimentary rocks in Manitoba and eastern Ontario are invariably polished and grooved in horizontal or nearly horizontal planes, with abrupt faces or escarpments at changes of level, never rounded into domes or *roches moutonnées.*

Post-glacial Disintegration.

In this partially flooded area of *roches moutonnées* which we may consider as constituting the basin of the Lake of the Woods, there have been going on in post-glacial times very active processes of erosion, but owing to the brief geological time that they have been in operation, their effects have had an insignificant influence upon the general features of the country in comparison with that which went before. The chief of these is the shore erosion acting along lines defined by geological structure, the principle of which has been already spoken of. The rock debris along nearly all the shores of the lake basin is of two kinds, that which has been dropped as erraties in their passage, and that derived from the immediately adjoining rocks, which has been detached since the lake assumed its present shape. There is a considerable talus of angular blocks at the base of all precipitous cliffs, due to the combined action of frost and gravity; and not infrequently a wall of rock is seen to be shattered and torn as if by a violent explosion. The cause of these disruptions is said by the Indians to have been lightning. Forest fires have been very effective agents in bringing about the coarse disruptions of the rocks of the region. If a camp fire be built on a bare surface, the rock beneath it will have been shattered and peeled off from a depth of an eighth of an inch to an inch or more by the time the kettle has come to the boil. When a forest fire sweeps a country, this same cracking and peeling off of the rock, due to the excessive expansion of the surface, takes place on an

Shore erosion.

extensive scale. As a rule, there is little or no soil to protect the rocks, the trees growing in fissures or in small patches of sand; and the mosses which conceal them burn for days after the half-charred trees have ceased to smoke. The slabs or tablet-like fragments of rock thus separated are found strewn over the sterile country of the region. The slabs are, as a rule, slightly curved and concentric with the rounded, generally glaciated, surface from which they are detached.

Action of fires.

Concentric weathering.

This same tendency of the rocks to peel off in concentric layers is exhibited in situations where fires could not have been the cause. The phenomenon is seen chiefly in granitic and gneissic rocks and occasionally in massive basic rockss. The rocks are nearly always rounded in shape and are seen to be peeling off at the surface in curvilinear sheets. Sometimes it is possible to detach these sheets of rock with the fingers, but in the majority of cases they are firmly adherent to the main mass of the rock. Often two or three such layers or sheets are seen one above the other, the outermost extensively removed and the inner least so, forming a miniature series of steps. The thickness of the layers is generally about a quarter of an inch. The tendency of the rocks to become disentegrated in the fashion indicated, though not attributable to the agency of fire, since it can be seen below the high-water mark, is doubtless due to the operation of the same internal forces less actively excited, viz., the unequal expansion of the rock at different depths from the surface due to variations in temperature.

Action of vegetation.

In a region where soil is so scanty, vegetation plays an important part in the coarse disintegration of the rocks. The roots of trees are everywhere prying up blocks of the rock into the joints and fissures of which they have penetrated, and it is no uncommon thing to find angular masses, several tons in weight, lifted one or two feet out of their natural resting place, or even dislodged entirely by the slow growth and expansive force of the roots. The lower forms of plant life are also active agents in dislodging and bringing to lower levels the loose blocks formed by jointing and cleavage. The growth of mosses and grasses in the cracks of rocks is constantly attended by the movement or pushing out of the angular blocks, wherever such movement is possible. This movement, however, is doubtless partially due to the congelation of the moisture that would naturally accumulate in such a plant-filled fissure, as well as to the expansive force of the vegetation itself.

Other denuding agencies.

Animals, too, are not without their influence in the dislodgment of loose blocks from higher to lower levels. One has only to walk through those portions of the region where bears are common to observe the large numbers of rock fragments that these powerful animals have

pulled from their places or rolled over in their search for ants and grubs. These are the more manifest forms of rock disintegration at play. Other subtler forces are however at work, such as those of surface solution and mechanical wear, but their effect has been, as is amply shown by the distinctness of the grooves and striæ, so extremely slight, that they do not require to be noticed here, beyond observing that there is quite a perceptible difference in the measure of their action upon those rocks, exposed on the top of the bare domes and ridges to the full influence of aërial agencies, from that upon the rocks near the water-level or below the high-water mark. The striæ and grooves below high-water mark are always much fresher and more distinct than those on bare surfaces higher up. The present aspect of the glaciated rock surfaces along the water's edge bears much the same relation to that of the lichen-covered rocks away from the water, as a polished and engraved surface of steel might do to that of a similarly engraved but rusted piece of iron. The waters of the lake have evidently had a protecting influence upon the rock surfaces along their shores, keeping them from the organic acids of vegetation and the carbonic acid of the atmosphere, which have eaten into the surface elsewhere, and rendered the grooves and striæ faint and sometimes scarcely perceptible.

Weathering of glaciated surfaces.

General Character of the Rocks of the Region.

Study of these rocks as yet incomplete.

The rocks here designated as the Keewatin series are of much interest, whether regarded from a purely petrological or from a geognostical point of view. Not only would a thorough study of these ancient altered schists and their associated massive rocks be of the greatest value to lithological science, as such, but the knowledge derived from such a study is almost an essential preliminary of any investigation as to the origin and natural history of the series. Such a study, it is to be regretted, these rocks have not received, at least with that scientific thoroughness which their full comprehension demands, excepting in so far as I have been aided by the kindness of Dr. G. H. Williams, of John Hopkins' University, who has had a collection of the more interesting rocks lithologically examined by Mr. W. S. Bayley, under his own supervision. For rocks not so examined I can only give the general microscopical character, upon which, supplemented by the results of Mr. Bayley's microscopic examinations, the lithographical mapping of the area is based.

The rocks of the region may, for convenience, be considered under the

following classification, in which regard is paid as much to their geological relations as to their lithological character. Classification of rocks.

Gneiss.
Granite.
Felsite, Micro-granite, Porphyry.

Schistose hornblende-rocks.
Diabases aud Diorites.
Serpentines.

Coarse Clastic rocks and Agglomerates.

Mica-schists, Micaceous slate, Quartzites, Clay-slates.
Felsitic schists.
Soft Hydromica-schists and chloritic schists (with other soft silicated magnesian schists.)
Carbonaceous schists.

Limestones.

In the following brief descriptive summary of the rocks, Mr. Bayley's report on the microscopic sections he examined for me will be largely drawn upon, and, indeed, almost entirely incorporated with my own notes, from which, howover, it will be readily distinguished by being placed within quotation marks.

Gneissic Rocks and Granites.

The granitoid gneisses, which underlie the Keewatin rocks, may be said to be characterized by a fairly well-marked and persistent porphyroid structure. The feldspar is the most abundant constituent, and most prominently developed crystallographically. Almost everywhere along the line of contact to the south of the Keewatin area, the gneisses are of very coarse textures, and this is true of the gneiss for considerable distances across the strike of the foliation, in some places the orthoclase crystals attaining a diameter of an inch or more, with a distinct, flowed structure of the other constituents of the gneiss around them, approaching typical augen-gneiss in appearance. General characters.

Another characteristic feature of the gneisses surrounding the area is their passage into granites devoid of foliation. The rock in the vicinity of Pine Portage mine, to the east of the contact with the schists, in which the shaft is sunk, is a reddish, to mottled flesh-tint and green, coarse-textured rock, of eminently granitic aspect. All the constituents, orthoclase, mica and quartz, are well developed and coarsely crystalline, and there is no trace of gneissic foliation. The rock is described as follows by Mr. Bayley.—

Gneiss near Pine Portage Mine.

Section No. 11. "Very much like section No. 15. It may, however, be considered as a porphyritic granite. Though there is nothing in the slide examined to show that the quartz and felspar grains of different sizes are not of the same generation, it seems better to class this among porphyritic granites, since the ground-mass, though not fine-grained, appears as micro-granitic when compared with the larger crystals. The quartz is water-clear, and contains very small fluid inclusions with movable bubbles, and fine, black needles, probably of rutile. The orthoclase is charged with kaolin. The plagioclase, as in No. 15, is fresher than the orthoclase, and possesses the same twinned structure. It has in it inclusions of epidote and the same black needles noted in the quartz. The biotite is slightly darker than in No. 15, and is accompanied by titanic iron, leucoxene and green epidote. In same cases it is decomposed, giving rise to a slightly pleochroic, dark-green, aggregate of small scales. In other respects it is very much like No. 15."

This rock, so characteristically granitic in its nature, may be traced eastward over a comparatively bare country, and be seen to assume gradually, by transitions scarcely perceptible, a gneissic arrangement of the crystals, till at last, on the shores of Long Lake, it presents a quite distinctly gneissic foliation, and, as will be shewn elsewhere, presents more and more the character of an intrusive breccia in proportion as the gneissic foliation becomes more distinctly developed toward the south east.

Gneiss of Dog-tooth Lake, etc.

The gneiss of Dog-tooth Lake, South Arm, is granitoid, but still distinctly foliated. The feldspar predominates in large crystals, giving it a porphyroid aspect. The quartz is in clear irregular grains and masses, and the black mica is in small, thin, uniformly arranged flakes, with which are associated a yellowish epidote-like mineral. The rock is reddish to salmon-color and apparently passes into varieties of the same rock which are quite granitic and devoid of foliated structure.

Near the head of the Rushing River, on the same lake, the gneiss is a gray, coarse-textured, faintly foliated rock, composed of nearly equal proportions of whitish felspar and clear quartz, with somewhat sparsely disseminated black mica in thick tablets and thin flakes.

Between Blind-fold Lake and the junction of gneiss and schist on Hollow Lake, the rock is a coarse, gray, well-foliated gneiss, composed chiefly of white felspar and black mica, but with a considerable proportion of quartz. Mixed with the orthoclase are a number of plagioclase crystals distinctly striated. This gneiss forms the matrix of a breccia in which the included fragments are blocks of hornblende-schists derived from the Keewatin rocks with which the gneiss is in contact half a mile to the south.

Of the gneisses to the south of the belt, that of Astron Bay may be taken as a fairly representative type. Near the junction with the schists it is of a more or less granitoid aspect, with thin, sharply defined micaceous foliæ, not continuous, but uniform in direction. It is of coarse texture and very quartzose. The felspar is apparently all orthoclase, varying in color from white to flesh tinted. Half a mile to the south of the contact, the gneiss is more coarsely textured and less evenly foliated. The proportion of quartz is less and there is present a quantity of plagioclase in finely striated crystals. The color of the rock is a pepper-and-salt gray.

Gneiss of Astron Bay.

The gneiss in contact with the hornblende-schist on the south side of Birch Island is microscopically a grayish, medium-textured, foliated rock, composed of whitish felspar and quartz, with sharp, thin, leaf-like foliæ of black mica uniformly arranged, and with needles of a black hornblendic mineral. Microscopically, Mr. Bayley reports on it as follows :—

"Section No. 4 is a typical gneiss. It consists of a tolerably fine-grained ground-mass of quartz and orthoclase, containing shreds and plates of biotite arranged parallel to the lines of schistosity. Considerable green hornblende mixed with a little biotite and hæmatite are massed together, forming aggregates whose longer diagonals are parallel to the schist plane. Besides these, well developed individual crystals of hornblende also occur. In this ground-mass large crystals of feldspar are numerous. A little orthoclase with zonal structure is twinned according to the Carlsbad law. Beautiful plagioclase in irregular broken pieces shows evidences of pressure twinning. The twinning lamellæ are bent and in a few cases the crystals are broken and faulted as if they had been subjected to considerable pressure. They all possess a well marked zonal structure and are twinned according to both laws. The larger pieces are surrounded with little mica plates. The orthoclase is just a little cloudy with decomposition products. Apatite, epidote, titanic iron and leucoxene are the secondary minerals."

Microscopical characters.

The gneiss on the west side of Shoal Lake, near Snow-shoe Bay is a reddish rock composed of orthoclase and black mica, with quartz as a less prominent constituent. The foliation is rough and irregular, but distinctly gneissic.

Gneiss of Shoal Lake.

The gneiss of Quarry Island, a boss, apparently intrusive, projecting through the firm hornblende-schist of the north-eastern portion of the lake is an exceedingly coarse, roughly foliated porphyroid rock, in which the feldspar is present in crystals often half an inch or more in diameter, very cleavable and of a white color with a faint lilac tint. Black mica is plentiful and is gneissically foliated, not in flakes or tablets,

but in irregular aggregations of fine scales. Quartz is not abundant, but is noticeably of a milky blue color. A prominent accessory mineral is molybdenite in fine scales, which, however, appears to be rather associated with fine quartz veinules than to exist as a constituent of the rock. The rock though quite distinctly foliated in some portions of the mass is in others almost quite granitic in its texture.

Gneissic foliation in granite dyke.

A good instance of the gneissic foliation assumed by granitic intrusion is that afforded by a dyke, cutting hornblende-schists transversely on a small island two and a-half miles south-west of Yellow Girl Point. The dyke is apparently an offshoot from the larger granitic mass which occupies the south half of Beacon Island, which is itself for the most part granitic in texture but foliated in places, particularly near its contact with the schists. The dyke is about fifteen feet wide and crosses the small island from south to north with a curved direction as represented in the accompanying diagram.

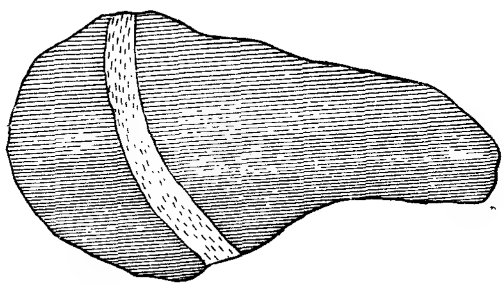

FIG. 2.—FOLIATED GRANITE DYKE, CUTTING SCHISTS.

The rock of the dyke is foliated in a direction parallel to its walls, but this foliation is much more prominently developed towards the sides of the dyke than in its central portions. The rock is of a pinkish-grey color and the foliation is somewhat wavy. Its lithological characters are thus described:—

Microscopic characters.

"Section No. 45. Gneiss very similar to No. 4. It contains less mica and hornblende and more feldspar, both in porphyritic crystals and in the ground-mass. The feldspar, both orthoclase and plagioclase, is much more decomposed, and consequently the whole slide is filled with sheets of muscovite. The plagioclase has the true microcline structure. A few round grains of clear quartz and quite a quantity of calcite also occur, the calcite filling in between the other constituents."

The Yellow Girl granite mass may be taken as the type of the intrusive granites of the region. As will be gathered from the map,

this granite occupies the central portion of the Eastern Peninsula, and constitutes the nucleus of a great area of upheaval, around which the strata trend, tilted at high angles. Microscopically, the rock consists of a granular ground-mass of reddish to flesh-tinted felspar, quartz and mica, in which are imbedded large porphyroid crystals of orthoclase and occasional smaller crystals of striated plagioclase. Its microscopic characters are given as follows :—

Yellow Girl granite.

Microscopic characters.

Section No. 15.—"This rock is a typical granite. Under the microscope it is seen to be composed of irregular grains of limpid quartz, orthoclase, plagioclase and a little pleochroic green biotite, which has been slightly bleached around the edges.

"The quartz contains numerous liquid inclusions with little dancing bubbles. These inclusions are generally arranged in lines and have the form of negative quartz crystals. In addition to these, the quartz contains beautiful little crystals of sphene (∞ P and O P), and a few octahedra of magnetite. The orthoclase is almost all changed into kaolin. It contains also little hexagonal plates of hæmatite. The plagioclase is fresher and shews a beautiful zonal structure, as does also the orthoclase in some cases. In one instance, six distinct bands were very clearly discernible on a slightly decomposed orthoclase crystal. The plagioclase is twinned according to both the albite and pericline laws, and in many instances possesses the appearance of having been bent. This is particularly well seen in those long crystals which have very fine twinning lamellæ.

"The biotite is slightly decomposed, and is accompanied around its edges by sphene and slightly pleochroic grass-green epidote in very ragged grains. Apatite crystals are rare. Small particles of magnetite are scattered through the interstices between the other constituents, especially around the mica, and these, on oxidation, change into the sesquioxide, which stains the rims of the quartz and feldspar red."

Granite near Wind-fall Island.

Another specimen of granite, of which a section was examined, is that of a dyke running parallel with the schists on a small island south of the extreme west point of Wind-fall Island. It is a light greenish-gray, rather finely granular rock, resembling rather a felsite than a granite in its general aspect. It is thus described.—

"Section No. 6 is a true granite (biotite-muscovite granite). This slide shews that the rock is composed essentially of small plates of pinkish-brown biotite, slightly pleochroic, small plates of green hornblende, round grains of quartz and feldspar and considerable muscovite. The quartz is limpid, with irregular gas- and oval fluid-inclusions, rarely apatite crystals and frequently slender, black needles. The feldspars are like those in Nos. 15 & 11 the plagioclase, however, being much clearer, and the orthoclase containing a great many inclusions of

various kinds. The muscovite is in tolerably large plates and includes small crystals of the other constituents of the rock. Among the accessory minerals are plates of green hornblende, small grains and crystals of magnetite, little plates of hæmatite and apatite needles. Some of these have been broken and bent about, the broken pieces making an angle of about 135° with each other."

Felsites.

Closely connected with the granites of the Keewatin area, is a series of intrusive felsites. These, as will be noted farther on, break through the schists in the vicinity of granitic masses, with which they are probably genetically connected, although they have cooled more rapidly and under other different conditions. They occur in dykes and irregular masses which shew a tendency to arrangement more or less concentric with the confines of the main granitic mass. A good typical example of this felsite is that of which a section has been examined from an island in Shoal Lake, just to the west of the peninsula separating Bag Bay from the main body of the lake. The following are Mr. Bayley's notes on the section.—

Micro-felsite from Shoal Lake.

"Section No. 42, is a micro-felsite. Under the microscope, in polarized light, it appears as a very fine-grained mosaic of quartz and feldspar, with here and there a somewhat larger grain of limpid quartz, or clear plagioclase, and frequently a little irregular patch of secondary calcite.

"Scattered through this ground-mass are plates of very light mica, surrounded by rims of decomposition-products, crystals of sphene and a very small amount of biotite. In the slide examined, there were only a very few shreds of green-brown mica, mixed with magnetite. The most interesting mineral in this rock is a blue tourmaline. It is strongly pleochroic and is grouped like a tuft of grass. It is most common around grains of pyrite, which have begun to decompose. The other products of this decomposition are hæmatite and an ochreous stain, which penetrates the general mass for some distance around each decomposing particle."

Felsite from Echo Bay.

On the north side of Echo Bay another patch of felsite, of a purplish colour, occurs to the north of the Canoe Lake granitic mass, which is thus described :—

"Section No. 28 is very much like No. 17. The hornblende is darker in color. The plagioclase shews feebly the original twinned structure. The quartz contains liquid inclusions with bubbles.

"It differs from No. 17 in containing a great deal of calcite all through the ground-mass, in irregular patches between other constituents as well as in little colourless rhombohedrons. Perfectly developed brown

rhombohedrons also occur. They are probably dolomite or calcite. The massive calcite is often coloured with ferric oxide, when it takes on exactly the same appearance as is seen in these little rhombo hedrons. They are most frequent in the neighborhood of a vein of quartz-mosaic which runs through a portion of the section examined."

Feldspar-porphry, Quartz-porphry, Serpentine.

Between the two great granite masses of Portage Bay and Carl Bay, and separated from them by intervening belts of hornblende-schists, is a somewhat extensive area of a purplish-grey feldspar-porphyry. The rock is apparently a large intrusive mass, and is probably akin in origin to the regular granites in close proximity to it on either side. Its lithological characters are thus given.— **Feldspar-porphyry.**

"Section No. 44 is an altered felsite with porphyritic crystals of plagioclase. If eruptive, it might be classed with the micro-granites. A very fine-grained ground-mass, contains octahedrons of magnetite, small plates of brown biotite and considerable calcite. In this are imbedded larger, irregular grains of calcite, large pieces of plagioclase crystals with twinned structure, though cloudy with decomposition products, Carlsbad twins of orthoclase, with zonal structure, and aggregate of brown mica, bleached mica, (probably muscovite) magnetite and hæmatite."

An intrusive rock of another kind is that described by Mr. Bayley as:—

"Section No. 33. Quartz-porphyry. This rock consists of a micro-crystalline ground-mass of quartz and plagioclase, forming a mosaic of round clear grains. In this ground-mass are large crystals of plagioclase, twinned according to both the albite and pericline laws and consequently having the twinned lamellæ making an angle of 86° with each other. These large crystals have begun to undergo alteration into kaolin. Large grains of water-clear quartz contain inclusions of the ground-mass, mica, and now and then a crystal of light-yellow zircon. Besides these are the usual fluid inclusions with movable bubbles. **Quartz-porphyry.**

"This originally contained a green mica with rutile needles like that described by Dr. Williams from Tryberg. Very little of the original mica remains. Most of it has been changed, giving rise to a brown ochreous substance which has separated out and left a perfectly colorless mica. The rutile, being less liable to alteration, has been left in its original position and now appears as brown needles arranged along cleavage lines of the bleached mica, or cutting each other at an angle of about 60°. Other products of this decomposition are pyrite, titanic iron and leucoxene."

Association of rutile and biotite.

Another view of the association of the rutile needles with the mica is that given in a footnote to Mr. Bayley's report by Dr. Williams who remarks:—"The association of this mineral with the decomposed biotite is very interesting. In this case, however, it appears not to have been an original inclusion in this mineral, as Mr. Bayley thinks, but rather a result of alteration. Rutile in de composed mica has been very frequently observed by Zickel, Cross, Sandberger and others and owes its origin to the separation of the TiO_2 which so many biotites contain in their fresh state. This more rarely appears as anatase or sphene. (The latter mineral seems to have been formed in some other cases described as in Section 42, &c.) The only instance recorded of rutile in fresh biotite is that above mentioned. The other explanation is however here more probable."

Association of quartz-porphyry and serpentine.

The quartz-porphyry, whose lithological characters have been just detailed, occupies the greater portion of a small island, two and three-quarter miles south-west of Wiley Point, and is evidently associated with a mass of serpentine which occupies a small island beside the north, and the neighboring point on the main shore a little to the south-west. The serpentine on this point presents no definite relations to the other rocks, beyond the fact that it is in contact to the west with dark-green somewhat chloritic hornblende-schists, and that on the east, the point is tipped with a nob of hard crystalline dioritic rock. On another point of the shore, one and a-half miles to the north-east of this, occurs a second mass of serpentine, under conditions very similar to those just described. It is in contact to the west with green schists as before, and the extremity of the point occupied by the same dioritic rock, but with this difference, that between the diorite and the serpentine there is a dyke fifteen feet wide of the quartz-porphyry, evidently an offshoot from the main mass occupying the island off-shore a little to the south. The masses of serpentine on these two points and on the small island in immediate proximity to the quartz-porphyry are nearly in a line, and also in a line with the general strike of the rocks at this locality; but whether the serpentine is interbedded with the schists, or was originally intrusive, it is difficult to say from the evidence available in this particular case. The presence of the quartz-porphyry as an intrusion, associated with what appear to be dykes of diorite striking parallel to the dyke of quartz-porphyry, would seem to warrant us in regarding all these rocks—serpentine, diorite and quartz-porphyry—as different manifestations of outflows along a line of fissure, probably at widely separated intervals, and altered according to the well known tendency of these rocks, or rather of their original forms.

Other associations of serpentine.

Having proceeded so far with the description of this serpentine in connection with its association with the quartz-porphyry, it is desirable to give here its lithological characters rather than defer it to a more systematic place. In the same rock mass there are two varieties. One of these is a finely granular mottled purple and green, rather hard rock, while the other is a more coarsely granular, uniformly dull-green softer rock. Both of these are in places quite schistose, though for the most part massive. Little short segregations of chrysolite or picrolite with here and there a well-defined vein of ribanded chrysolite and white dolomite, run through the rock. There is a sufficiently large proportion of magnetite in it to create a marked deflection of the compass. The first of these two varieties is described by Mr. Bayley as follows.— **Two varieties of serpentine.**

"Section No. 32. In this rock the forms of the original olivine can be clearly seen. There is no trace, however, of this mineral left. It has been completely changed into fibrous serpentine. The spaces between the rounded grains of serpentinized material are filled with calcite, in which are scattered chromite, hydrated oxide of iron, and a cloudy, grey opaque substance in very fine dots." **Microscopic characters.**

The following note is descriptive of a section of the second variety.—

"Section No. 31 was probably originally a rock very much like Section No. 5. It has undergone alteration to such an extent that it is impossible to determine whether there was any olivine in the fresh rock or not. As it now occurs it is made up almost entirely of serpentine, with some remains of a fibrous mineral, with an extinction of 0°—2°, and quite a quantity of the ordinary iron minerals.

"The fibrous mineral is probably enstatite, and would, if it were fresh, give sharper extinctions. The extinctions are never interfered with by fibres of serpentine running through the length of the minerals."

Schistose Hornblende-rocks.

The general macroscopic characters of these rocks are best described by noting the different forms under which they appear. These are first, a very hard and tough, compact, fine-grained black rock, with scarcely any definite schistose structure perceptible in it. Secondly, they occur as rocks differing from the last only in having a well-defined, slaty or schistose structure developed in them. These are also, perhaps, a little coarser grained, and as a consequence of the schistose structure, are not nearly so tough under the hammer. This slaty or evenly schistose, black hornblende-rock, is usually the basal formation of the Keewatin series, and lies in contact with the granitoid gneisses. When the granites break through hornblende-schist, the latter may be either of the massive or the schistose variety of the black hornblende- **General character.**

schists. The term schist is retained for the massive variety, since, although of comparatively the same coherence in all directions, microscopically the crystals appear to have a parallel arrangement. Other varieties of hornblende-schists prevail, but they are usually green, of medium dark tint, and more or less chloritic. A few specimens of the more massive and less evidently hornblendic varieties of these rocks, have been examined, and an account of their microscopical characters will be of service in conveying an idea of the nature of an important and characteristic part of the belt of schists we are considering.

Specimen from Separation Point.

Section No. 41, is from a stratified rock on the end of Separation Point. The rock is not here a part of a hornblendic group, but is associated and interbedded with a series of agglomerate-schists, with which it is consequently grouped in the mapping. The banded structure described by Mr. Bayley as characterizing the section under the microscope, is true of the rock on the large scale, though the strata appear contorted. The following is his note on the section.—

"It is a banded horneblende rock. It consists principally of small, irregular pieces of fibrous green hornblende with a ground-mass of quartz arranged in some places in mosaic masses with irregular outline. The other constituents of the rock are small crystals of hornblende with twinned structure, a few plates of brown biotite, a small quantity of plagioclase almost completely changed into sassurite and a little pyrite.

"Under the microscope, the section examined shewed a distinct banding of layers containing varying amounts of hornblende. Macroscopically, however, it appears as an eminently massive rock. Hence it is impossible to decide, apart from field study, whether it is an amphibole-schist or a metamorphic eruptive rock."

Specimen from Big-stone Bay.

Section 12 is that of the tough, compact, fine-grained rock that occupies so extensive an area in the vicinity of Big-stone Bay, and forms the contact rock with the Laurentian granitoid gneisses along the eastern confines of the Keewatin area. The particular specimen examined is from near the shaft of the Pine Portage mine. It is described as resembling No.41. The minerals forming it are woven together, producing a compact, massive-looking rock. It is not quite so coarse grained as No. 41. There is a little more hornblende, which is darker and more fibrous. The plagioclase has been changed into epidote. A little quartz, with hornblende inclusions and small grains of magnetite scattered all over the rock, complete its list of constituents."

Rock from White-fish Bay.

The next specimen of these hornblende-schists, of which a section has been examined, is one typical of the schists in contact with the granitoid gneisses at the nort end of White-fish Bay on the southern

confines of the belt. It is taken from a small island near the narrows which lead from the bay out to the lake.

"Section 23.—This rock is very peculiar, reminding one of the 'feldspathic hornblende-schist' of Wichmann. It consists of parallel plates of green hornblende in a ground-mass of feldspar in irregular rounded grains, and sometimes in long crystals. This feldspar is fresh and some of the crystals are twinned according to the Carlsbad law. The hornblende is compact and feebly pleochroic. Grains of magnetite mixed with hæmatite occur here and there, staining the rims of the hornblende with a brown, ocherous stain. Apatite and sphene, epidote and very thin shreds of biotite occur in small quantity in the ground-mass. In addition to the comparatively small amount of plagioclase in the ground-mass, there are very large porphyritic crystals, apparently made up of several individuals. These porphyritic crystals have, in general, the outlines of a crystal of feldspar. The extinctions in the faces could not be measured in consequence of their polysynthetic nature. The different individuals are twinned. Those in the centre are perfectly fresh, while those near the edges are decomposed, the alteration products being sassurite, hæmatite, magnetite, quartz containing acicular crystals extinguishing at 40°–42°, and an indeterminate granular substance. Around the edges of this large crystal, the hornblende crystals are massed as if they had been pressed against it by some force acting perpendicularly to the planes of schistosity."

Specimen from near Wiley Point.

Section No. 1 is that of a specimen of a series of green hornblende-schists taken from an island three-quarters of a mile east-south-east of Wiley Point. The rock is peculiar in having contained in it pebble-like portions of a light-gray, felsitic material, the line of demarkation between which and the schistose hornblendic matrix, which constitutes the main mass of the rock, is very sharp. This is the "lighter portion" of the section referred to by Mr. Bayley, who writes as follows upon it.—

"Section No. 1 is very much like No. 23. The porphyritic crystals, however, are much smaller and are much more altered. The hornblende is much lighter in color and considerable biotite has been developed. The hornblende and mica are arranged in bands in a very fine ground-mass of feldspar and calcite. Almost all the plagioclase, both in the porphyritic crystals and in the ground-mass is entirely changed into sassurite. Titanic iron and leucoxene are scattered through the ground-mass.

"In the lighter portion of this same rock the plagioclase predominates and the hornblende is almost entirely lacking. In addition to the plagioclase, which, as in the darker portion, is highly altered,

there is considerable calcite, the two forming a ground-mass in which there are numerous grains of titanic iron. Most of these are surrounded by leucoxene."

Specimen from Wiley Point.

About seventy-five yards south-west from the extremity of Wiley Point, the micaceo-feldspathic schists are cut upon the shore by an irregular intrusion, a dark, gray rock containing numerous sharply-defined porphyritic crystals of calcite, which, on the weathered surface, have been completely dissolved out, leaving angular rhombohedral cavities, which give the rock a peculiar pitted appearance. Mr. Bayley classes the rock with the schistose hornblende rocks, and thus describes it.—

"Section No. 3 is a sort of hornblende-schist with porphyritic calcite. The ground-mass is composed of fine grains of feldspar with slightly larger grains of hornblende, calcite, and a little biotite, titanic iron, and leucoxene. The plagioclase is dusty with inclusions and contains a few brightly polarizing needles. For the most part it is fresh and twinned according to a single law. The mica is brown, the hornblende, green. They are in about the same proportion, and together make up not more than a tenth of the whole rock. The calcite is in irregular grains, as if it were developed in cavities. The porphyritic crystals are all calcite. It forms perfectly developed rhombs, with very distinct cleavage lines. This calcite contains numerous inclusions of hornblende, plagioclase, both fresh and altered, titanic iron and other little irregular patches of calcite, which are often twinned. In addition to these, there are also inclusions of the fine-grained ground-mass and little quartz grains. The occurrence of calcite in this rock reminds one of the amygdaloids of Pumpelly and Irving."

Specimen from Yellow Girl Bay.

Another rock classed by Mr. Bayley with the hornblende-schists is a very calcareous, greenish-gray schistose matrix of an agglomerate on the south side of the north-east arm of Yellow Girl Bay.

He says of it:—

"Section No. 20 is very much like Section No. 3. It contains a little quartz in the ground-mass. The plagioclase is sassuritized, and in other respects the rock is less fresh. In structure, the rock is eminently schistose. Quartz mosaics, aggregates of biotite and hornblende, mixed with hæmatite and magnetite, and oval masses of calcite all occur with their longer axes parallel. The calcite masses are comcomposed of twinned individuals. Titanic iron and leucoxene are scattered throughout the whole mass."

Diabases and Diorites.

Association with hornblende-schists.

Intimately associated with the schistose hornblende-rocks are great masses of dioritic and diabasic rocks, both schistose and massive. These rocks are for the most part interbedded with the hornblende-schists. sometimes regularly and at others in short non-continuous masses, such as might be expected as the condition of occurrence of ancient flows. For purposes of mapping it is impossible in the wild and uncleared state of the country to separate these diorites and diabases from the hornblende-schists into which, indeed, they seem at times to merge by gradations that make any attempt at a hard boundary quite out of keeping with the natural conditions.

Of these rocks, fourteen sections have been submitted for examination, an account of which will give a very fair idea of the representative kinds that are to be found in the area under consideration. These specimens are grouped by Mr. Bayley as follows, the detailed description of the sections corresponding to the respective numbers being given in the succeeding pages.

DIABASES AND DIORITES.

Classification.

	34. Typical diabase (augitic).
Typical "Greenstones." Altered traps.	27, 36. Entirely uralitized; structure "ophitic."
	35. " " structure partly "ophitic."
	19, 18. " " " wholly granular.
	30, 21, 22. Films of hornblende and sassurite.
	10, 16, 37, 25. Even more altered. Films of hornblende, sassurite and calcite.
	43. Typical diorite.

The rocks classed under this head, he remarks, form a regular series from the typical diabase (34) through altered diabases to the typical diorite (43).

Diabase of Falcon Island.

Section No. 34 is that of a mottled grey granular rock which forms a dyke sixty feet wide, cutting the Laurentian gneiss, with a strike due south, on the west side of Falcon Island, near the contact with the Keewatin. It seems not improbable that such a fissure in the gneiss may be only the exposed remnant of an extensive system of vents whereby the Keewatin trough was supplied with the volcanic material which now fills it, although the comparatively little-altered state in which Mr. Bayley finds the section examined by him, might suggest a very much more recent origin for it and give it a place in that series of basic dykes which cut both Laurentian and other rocks throughout the region, and perhaps equivalent in age to the trap overflows of Lake Superior. The following are its lithological characters.—

"The rock is a typical diabase. It consists principally of augite, hornblende and feldspar. "The augite is in large, irregular pieces, of a yellow-brown colour, with very distinct cleavage and full of colorless and brown glass inclusions. Toward the edges it shows a fine striation, and on the outer rim is changed into an apparently compact green hornblende which is strongly pleochroic. The plagioclase is in the usual lath-shaped crystals with twinned structure.

"The accessory minerals are dark biotite, very strongly pleochroic, mixed with magnetite and secondary hornblende. Secondary quartz with glassy (?) inclusions in some places fills the interstices between the feldspar. The plagioclase in the ground-mass is nearly all changed into sassurite, in which other minerals appear porphyritically. In addition to its alteration into hornblende, the augite is changed in many places into a fibrous grey mineral clouded with little black dots. The structure of the rock is that of a typical diabase."

Altered diabase Cork-screw Island.

The rocks on the southwest extremity of Cork-screw Island in Ptarmigan Bay are much broken by intrusions of flesh-red granite. The rock that the granite cuts in parallel dykes is very hard, dark and compact in texture, with considerable pyrites finely disseminated. The section of it that has been examined presents the following characters.—

"Section No. 27, though containing no augite, is evidently an altered diabase. The hornblende is fibrous, as if secondarily developed. The original structure can still be detected, where the decomposition has not gone too far. The ground-mass is composed of decomposed feldspar (principally kaolin), a little secondary quartz with numerous apatite crystals, and a few very fine needles polarizing in very bright colours. The hornblende is scattered all through this ground-mass thickest where the augite originally was. The plagioclase is in lath-shaped crystals which, in consequence of alteration, have lost almost all traces of twinning. Quartz (always secondary) occurs in irregular grains which, in polarized light, are found to be made up of numerous individuals forming a mosaic. Titanic iron and leucoxene are also present in abundance."

Altered diabase Devil's Gap.

The rocks exposed in the natural section afforded by the Devil's Gap near Rat Portage, are extensive masses of greenstone, with a felsite schistose structure developed in it in places, which seem to be interbedded with hornblende-schists. The more massive rock graduates into the distinctly laminated schists towards the south end of the Gap, so that it is impossible to draw a hard line between them. The massive greenstone is thus described :—

"Section No. 36, is also an altered diabase. Here the diabase is very pronounced. The augite, as in No. 27, is entirely replaced by light-green, fibrous hornblende (uralite). The plagioclase is in lath-shaped

crystals, which are brown from little inclusions. These inclusions are often heaped up in the centre or arranged around the rims of the crystals, which in other respects are perfectly clear and fresh. In other respects this rock is like No. 27, except that the titanic iron is almost entirely replaced by leucoxene, and in many places calcite has developed in the neighborhood of the plagioclase."

Altered diabase Rat Portage.

Section No. 35, is that of a specimen of a considerable thickness, of bedded crystalline trap-rock, which crops out upon the shores of the lake near Rat Portage, just to the south, and crosses the Canadian Pacific railway track, with an east-north-east strike, almost two miles east of the town. These trap beds are seen on the lake shore to dip north at a high angle, under beds of grey, very quartzose mica-schist, and to be in contact to the south, or in their upper portion, with beds of agglomerate. The specimen is from the cutting on the railway track.

"Section No. 35 is much coarser grained than No. 36. It consists principally of larger, irregular grains of beautifully fibrous hornblende and crystals of plagioclase. The hornblende is highly pleochroic, $\mathfrak{c}$ = blue-green, $\mathfrak{a}$ and $\mathfrak{b}$ = greenish-yellow, and comprises about two-thirds of the entire rock. The plagioclase occurs in two forms. The lath-shaped crystals are perfectly clear, and show the twinning lamellæ very distinctly. Some are brown, with inclusions, as in No. 36. That in the ground-mass is commencing to change into sassurite. The diabase structure is discernible only in a few places. Titanic iron and leucoxene are developed around the hornblende."

Trap, Yellow Girl Bay.

Section No. 19, is, from what appears to be a great interbedded sheet of trap, associated with hornblendic or micaceo-hornblendic schists, mica-schists and agglomerates, on the north-east arm of Yellow Girl Bay. Its characters are thus given.—

"The rock contains no trace of diabase structure. It is very coarse-grained. The hornblende is very fibrous, and bears all the marks of secondary development. It is highly pleochroic, $\mathfrak{c}$ = blue-green, $\mathfrak{b}$ = grass-green, $\mathfrak{a}$ = greenish-yellow. Long, slender needles penetrate into the surrounding ground-mass. The plagioclase is clear and in long crystals. Leucoxene is very abundant. Its development by alteration of titanic iron is very finely seen here. Large octahedrons are composed of mixtures of leucoxene and titanic iron in all proportions, and sometimes all traces of the original mineral have disappeared, leaving pseudomorphs of leucoxene. A little secondary quartz occurs in veins and mosaics."

Trap, White-fish Bay Narrows.

Along the north shore of the Grande Presqu'île in the neighborhood of the White-fish Bay Narrows, is a great thickness of light-green trap of varying texture, but for the most part coarsely crystal-

line. Stratigraphically, these traps occupy an intermediate position between the black hornblende-schists, that are in contact with the granitoid gneiss to the south, and a higher formation of softer, fissile, lighter green, chloritic, hornblende-schists, which lie upon them to the north. The characters of a specimen of this trap are as follows—

"Section No. 18 is less fresh than No. 19. The hornblende is very light green, and feebly pleochroic. Long, almost colourless needles extend far into the plagioclase of the ground-mass. Most of the triclinic feldspar is entirely changed into sassurite. That which has not undergone alteration is present in thin lath-shaped crystals. As in most of the other rocks of this series, quartz also occurs here in mosaic grains, filling in the interstices between hornblende and plagioclase. It is perfectly clear and contains apatite crystals (almost certainly of secondary origin). Leucoxene and titanic iron are also present. Besides these, there is a brownish mineral with very indistinct cleavage. It polarizes like an aggregate and appears to have undergone alteration of some kind. Its nature could not be determined without a chemical analysis."

Trap from Big Narrows Island.

Section No. 30 is from a mass of trap occupying the extremity of a point on the north shore of Big Narrows Island. It is in contact to the south with an agglomerate-schist, which dips to the south, and the trap is probably intercalated as a thick bed in it, though the evidence afforded by the exposure does not preclude the possibility of its being an intrusive boss. It is thus described:—

"The section contains no traces of diabase structure, not even a clearly-defined plagioclase crystal. It is more altered than any of the rocks heretofore considered. The hornblende is in patches all over the slide. It is light green and feebly pleochroic. The feldspar is entirely changed into sassurite, except in the case of a few porphyritic crystals. This sassurite, mixed with the hornblende, forms a ground-mass in which a large quantity of calcite, some of it in long, lath-shaped crystals surrounded by a brown rims, occurs. This calcite is evidently a pseudomorph after plagioclase, and if this is the case, the rock would probably be classed among the rest of this group as an altered diabase, although no crystals of plagioclase remains. In addition to these constituents, there also found in this rock quite a quantity of yellowish epidote in irregular masses, slightly pleochroic, a little sphene, and the usual leucoxene and titanic iron."

Trap, Yellow Girl Bay.

Section 21 is from the rock occupying the extremity of the point that separates the two arms of Yellow Girl Bay as a thick but not very well-defined bed in green schists. The rock itself, though coarse-textured and massive in aspect, displays a tendency to rough cleavage under the hammer.

"It is much more highly altered than No. 30. It consists of a ground-

mass composed of irregular masses of decomposed plagioclase, a little secondary quartz and considerable calcite, filling in interstices between plagioclase. The hornblende is in large, irregular fibrous plates and in small, well-developed crystals. The former are bluish-green and yellowish-green bleached on the edges to a perfectly colorless mass of fine, long needles. The latter seem to have been developed from the former, for they only occur in places where the larger plates have evidently been subjected to some decomposing agency. Here they are more ragged and of a brighter color than in any other portion of the rock and are always accompanied by titanic iron and sphene. The cross sections of the smaller crystals shew the cleavage lines and characteristic prismatic angles. Small plates of brown biotite occur mixed in with the hornblende, and apatite needles are scattered through the ground-mass.

"In all these highly altered rocks considerable calcite is developed through decomposition of the oligoclase."

Trap, Rendezvous Point.

Section No. 21 is from the rock of Rendezvous Point at the entrance to White-fish Bay. It is another specimen from the great trap formation described under No. 18. It is briefly described as being "even more decomposed than No. 21. The hornblende is not bleached quite so much and the smaller crystals are twinned. The plagioclase is altered to a considerable extent into sassurite, which, mixed with the fine needles of hornblende, give a granular appearance to the ground-mass. In all other respects this rock is like No. 21."

On a small island, about half-way between Pine Point and Heenan Point, an interesting association of rocks is met with. On the west side of the island are greenish-grey, rusty-weathering, fissile, chloritic schists. The strike of these schists bends from N. 30° E. to N. 20° E. going north and dip westward at angles varying but little from the vertical. At the north end of the island, the same schists are of a darker green colour, firmer texture, less fissile, and much less decomposed, so far as can be judged from microscopic examination. They are in contact to the east with a grey-green trap in a line parallel to the strata of the schists, and on the west with a bed or dyke of mottled, green, granular, crystalline trap, through which run small seams of an asbestiform mineral, whose fibrous structure is perpendicular to the vein-walls. This "greenstone" is in contact again to the west with a large vein-like mass of rusty-weathering, green, somewhat silicious limestone. The green schists have a thickness of about sixty feet; the grey-green trap to the east twenty feet to the water's edge; the mottled green trap about forty feet and the limestone an undefined thickness, but probably about twelve or fifteen feet. The microscopic characters of the limestone are given on page 60 C C. The mottled green trap is thus described.—

"Section No. 10 is similar to Nos. 21 and 22. The hornblende is a little lighter in colour and the colourless needles are longer and finer. Titanic iron and leucoxene are scattered all through it, and now and then a little crystal of hæmatite is discovered in it. Calcite, as usual, is not an infrequent constituent of the ground-mass."

From Andrew Bay.

Section No. 16 is that of a rather coarse-textured, mottled, green and white rock, from the north side of the east end of Andrew Bay. It is associated with hornblendic schists and is probably a bedded mass. It is noted as "Very much altered. Plagioclase originally predominated, but this has almost entirely changed into sassurite. Now and then a very opaque crystal remains that has not been completely altered. The hornblende is in comparatively small quantity. It is very light green and feebly pleochroic. Associated with it are sphene and leucoxene. Considerable calcite occurs in the ground-mass."

From Labyrinth Bay.

Section No. 37 is from the south side of a long island in Labyrinth Bay, and is found along the shores of the Shoal Lake Narrows at intervals in apparently thick-bedded masses associated with other greenstones, schistose and massive, and serpentines. The rock has a coarse but distinctly marked gneissic foliation of the hornblendic constituent. "It is even more altered than No. 16. All the plagioclase has disappeared and in its stead are lath-shaped, almost opaque aggregates of sassurite and other decomposition-products. The hornblende is very pale, almost colourless. Titanic iron, leucoxene and calcite are disseminated everywhere throughout the ground-mass, the first two especially in the neighborhood of the hornblende."

Section No. 25 is a third specimen of the trap formation noted in connection with Nos. 18 and 21. It is in the same line of strike as both of these and is about two miles to the west of the locality from which No. 18 was taken. A distinct schistose structure is developed in the rock in places and the schistose variety passes into the massive by almost insensible gradations.

Microscopically, Mr. Bayley notes that "it is also similar to No. 16. The hornblende is a little darker and more pleochroic. It is also much more fibrous, and in some places is covered with little grey dots."

On a point on the south east side of Windigo Island, about its middle, occurs a patch of coarsely angular dioritic breccia breaking through the granitoid gneisses that make up the greater portion of the island. A light grey, highly feldspathic mottled matrix holds sharply angular, mechanically broken fragments and blocks of a dark, almost black, rather finely textured rock, composed apparently chiefly of hornblende. Mr. Bayley's examination of a section across a contact of matrix and inclusion shows both to be essentially diorites, in the former of which feldspar predominates and in the latter hornblende. The included frag-

ments are probably portions of earlier eruptions or flows from the same vent that have solidified and been caught up as broken pieces by later and more feldspathic lavas. Its lithological characters in detail are thus given.

Diorite from Windigo Island

"Section No. 43. A typical diorite, consisting of irregular grains of plagioclase and dark-green, massive hornblende.

"The hornblende is compact $\mathfrak{c}$ = very dark black-green, $\mathfrak{a}$ and $\mathfrak{b}$ = yellowish-green, accompanied by irregular grains of pink-yellow sphene, and light-green epidote, with very little biotite around the edges, and a brown, granular mineral in rhombohedrons, the nature of which could not be positively ascertained. The plagioclase is fresh and shows beautiful twinning lemallæ, all of which, in some crystals are according to a single law, while in others both laws are followed and the lamellæ cut each other at an angle of 86°–87°. A small part of the plagioclase begins to shew a non-polarizing decomposition-product in the centre of the various crystals, as if it had begun to decompose around central inclusions. Apatite needles occur throughout the plagioclase and other constituents of the rock in large numbers.

" The slide examined was composed of two distinct portions, one very dark and the other very light, as if it were the contact of two distinct rocks. A microscopical examination, however, shewed that both portions could be considered as diorites. In the dark part, hornblende predominated, and the plagioclase was generally fresh. In the light part, plagioclase (oligoclase) predominated, and it was more decomposed. The structure of the rock is that of typical diorite."

Microscopic distinction between intrusive and bedded volcanic rocks.

In this collection of rocks, classed by Mr. Bayley as diabases and diorites, an interesting fact comes out, when their lithological characters are considered in connection with their conditions of occurrence in the field. This is that the extremes of his series, the typical diabase and the typical diorite, are erupted rocks cutting the granitoid gneisses beyond the limits of the Keewatin area, while all his transitional rocks, the "altered traps" are within that series, and occur apparently as bedded flows of volcanic origin, intercalated irregularly with sedimentary deposits. This distinction, so well-marked both in the field and under the microscope, points to a later and distinct origin for the typical rocks, and as has already been suggested on a previous page, they are possibly associated in age with the trap overflows of post-Archæan times, which had, as the seat of their greatest intensity, the Lake Superior basin, but which may have been manifested to a less degree over a region of wide radius.

The typical diorite, though placed at the extreme of a series of rocks classified according to their degree of alteration from an original diabase, cannot be regarded as having been derived from a diabase as

the "altered traps" are. It is in itself a rock of equal systematic importance with the diabase, and in this particular instance it seems to have suffered as little alteration from its original condition as the diabase at the head of the series. On the other hand, the manifestly altered and degenerate condition of those bedded traps of the Keewatin indicate, according to accepted notions of lithology, a much greater age, the degeneracy from the type being apparently a function of time to a great extent.

Serpentines.

This interesting class of rocks is not of extensive occurrence in the Keewatin area of the Lake of the Woods, but is found irregularly distributed in patches of rather ill-defined character and extent. Specimens of the serpentine occurring in association with the quartz-porphyry to the south-west of Wiley Point have already been described. On the island and shore of Shoal Lake Narrows serpentine is more largely developed than elsewhere in the region. It is associated with altered trap-rocks and hornblendic schists. A specimen of this serpentine is thus briefly described by Mr. Bayley :—

Microscopic characters.

"Section No. 38 is a typical serpentine. There is no trace of the original minerals from which the present rock was derived. The whole ground-mass is composed of serpentine fibres, without any regard to the crystalline form of the original mineral. In this ground-mass, chromite, magnetite and a hydrated iron oxide occur."

On the south side of Brick Island a boss of serpentine projects through the black hornblende-schists in the immediate vicinity of their contact with the gneiss (section No. 4.) The microscopic characters of this rock are thus given :—

"Section No. 5.—In this slide, considerable af the original olivine can still be detected. It is in large oval grains. These are broken into numerous pieces and in the cracks serpentinization has begun to take place. A fibrous, colourless mineral, which in all probability is enstatite, has also given rise to much of the serpentine. This mineral contains numerous inclusions of magnetite, and has, as nearly as could be determined, a parallel extinction.

"Under the microscope, with crossed nicols, the slide is seen to be made up principally of serpentine, with large inclusions of broken olivine and irregular pieces of enstatite. In addition to these, there is considerable chromite, hydrated oxide of iron, hæmatite and the gray, opaque substance noted in section No. 32. Mixtures of these substances mark the outlines and cleavage lines of the original minerals."

Impure serpentines or soapstones occur in a few localities, most characteristically, however, on the narrows to the south of French Portage. The soapstone or pipestone of Pipe-stone Point is simply a soft, decomposed, or steatitic variety of the green hornblendic schists, and is not used by the Indians for making their pipes.

Clastic Rocks—Agglomerates.

Association. Closely allied stratigraphically to the last group of rocks are the fragmental rocks, agglomerates, tuffs and boulder-conglomerates of the Keewatin series. These, in many places, merge directly into mica-schists, on the one hand, and through green, dioritic schist-agglomerate into hornblende-schists. This mergence is not due to any process of alteration or metamorphism. Although the rocks pass into one another in space, it cannot therefore be assumed that there has been an historical passage or change of one rock into the other. The mergence is due simply to gradually increasing differences in the conditions and material of deposition, either on the same horizon (in which case the conditions and material have varied with the place), or at different stages of the stratigraphical column, when they have varied with time of deposit. Metamorphic agencies, have, to a limited extent, affected the mineralogical constitution of these rocks, but have by no means destroyed or effaced their original characteristic differences. Rapid mergences from one class of rock-material to another are easily explicable upon the only hyposthesis that will afford an adequate explanation of the origin of this geological series, viz.: an extremely rapid process of deposition of intimately associated, and often alternating volcanic ejectamenta (both flows and tuffs) and aqueous sedimentation, the material for which was derived partly from the volcanic products and partly from the more silicious or acidic rocks which seem to have constituted the original floor of the trough. The development of secondary minerals in these different classes of rock-materials, and the effects of pressure upon their internal structure have left them quite as distinct one from the other, in spite of the transitional mergence as when originally deposited.

Effects of pressure on agglomerates The effects of pressure upon the coarser varieties of these fragmental clastic rocks are well defined, and are extremely suggestive of the general diminution of the thickness of the rock mass, in directions parallel to the folding, which the series has undergone. The included fragments of the agglomerates are nearly always more or less flattened or lens-shaped, the greatest planes in the fragments being parallel with the planes of schistosity, which are in the great majority of cases ob-

servably identical with those of the bedding. This lateral flattening or pulling out of these fragments is most characteristic of those of smaller size, say under six inches in diameter, when their original outlines are, for the most part, though not always obliterated. Large, fragments, varying in size from six inches to three or four feet in diameter, are not uncommon, and succeed better in retaining their original shapes, which seem to have been mostly angular. In a few instances I have made sketches of the shapes of some of the included fragments, to shew their broken or angular character, some even presenting in the excellent cross sections afforded by ice-polished surfaces, re-entering angles. On the north side of Big Narrows Island, these agglomerates are extensively developed, and the matrix or paste is principally a schistose greenstone, of rather heterogenous composition. The accompanying figures are typical of the shapes of the more angular fragments, the lenticular ones, however, preponderating.

FIG. 3, ILLUSTRATING THE ANGULAR SHAPES OF FRAGMENTS IN AGGLOMERATE-SCHIST, BIG NARROWS ISLAND.

Matrix and fragments similar.

Here, as elsewhere in these agglomerates, the included fragments appear to differ but little in composition and texture from that of the matrix, from which they are distinguished principally by a whiter or more yellowish, weathered surface, indicative of a higher proportion of constituent feldspar, and by a superior hardness which cause them often to project above the surface.

Fragmental rocks showing water action.

Fine boulder- or pebble-conglomerates, distinctly recognizable as such, are of comparatively rare occurrence and of limited extent, and seem to be only phases of the more abundant agglomerate in which shore action has come into play and rounded the fragments before their final enclosure in the paste in which they are embedded. These pebble- or boulder-conglomerates merge into the ordinary volcanic agglomerates. They are of two kinds, (1) those in which the pebbles are crowded close together with a very small proportionate amount of cementing material, and (2) those in which the pebbles are widely separated and the paste is a dark-green, fissile, soft, chloritic schist. They differ from the agglomerates chiefly in the fact

that, whereas in the latter the paste and included fragment are closely related in composition, in the conglomerates, the pebbles are distinctly of a different origin and composition from the paste, the pebbles being chiefly round or oval, smoothly worn pieces of felsite, while fragments of saccharoidal quartz are also not uncommon. The best instance of these conglomerates was observed on the north side of Crow-duck Lake. Good instances of pebble-conglomerates also occur near Point Aylmer and at Crow Rock channel.

Agglomerates generally quite angular.

By far the greater portion of the agglomerates, which constitute one of the most extensive rock formations of the area, seems to have been formed quite independently of shore action. Both paste and included fragments have evidently had a common origin, and been laid down together, perhaps not even always under water. At times, as on the west side of Middle Island, the paste itself appears to be altogether composed of angular chips or fragments of felsitic and trappean material, varying from one-eighth to one-half an inch or more in size, constituting a genuine volcanic tufa in which the larger lenticular and angular fragments are imbedded. When this is the character of the paste, included fragments of angular forms are more plentiful. Fig. 4 shows the shapes of a number sketched from the agglomerate on the shores of Johnston Channel, north of Falcon Island.

FIG. 4.—ILLUSTRATING THE ANGULAR SHAPES OF FRAGMENTS IN AGGLOMERATE-SCHIST, JOHNSTON CHANNEL.

These agglomerate-schists are often garnetiferous, and the presence of garnets is particularly characteristic of the more micaceous variety on the islands north of Falcon Island.

Concretionary structure.

Closely associated in appearance with the more lenticular varieties of these agglomerates is an apparently concretionary structure, which, from its occurrence in traps in other regions, has given to the rocks so characterized the name of "concretionary traps," although the structure is by no means confined to true traps. The association of this concretionary structure with the lenticular agglomerate is more than one of mere appearance, for it is most largely and most characteristi-

cally developed in rocks closely similar, as far as microscopical characters go, to the rather nondescript greenstone-schist that constitutes the paste of those agglomerates in that form alluded to as the dioritic schist-agglomerate. It is also found developed in amygdoloidal trap-schists, and in dark-green or black hornblende-schist. This structure consists in the rock being divided into more or less irregularly spherical or ovoid masses, varying in diameter from two or three inches to as many feet. These ovoid masses are not in close contact, but are separated from one another by an interstitial material. The concretionary masses are, at their points of nearest approximation to one another, generally about half an inch or an inch apart, no matter what may be their size, so that when the ovoid masses are large, the interstitial material appears in section as thin anastomosing sheets, in which is developed a schistosity parallel to the outlines of the ovoid masses they enclose. This interstitial filling is generally of a darker color, more chloritic, softer, and of a finer more homogeneous texture than the ovoid masses, and weathers out, often leaving the latter, in the sections afforded by glaciated surfaces, surrounded by sharp, little trenches.

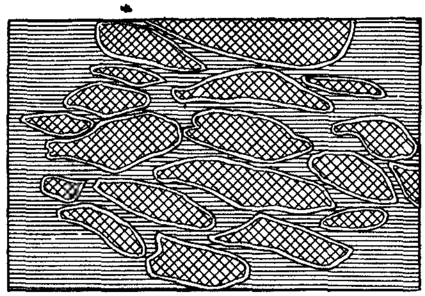

FIG. 5.—ILLUSTRATING CONCRETIONARY (?) STRUCTURE IN ROCKS ON KENNEDY ISLAND.

Section at Kennedy Island.

Fig. 5 represents the appearance presented in a natural horizontal section on the south-east corner of Kennedy Island. The rock is in the line of strike of a body of agglomerate-schists, into which it apparently merges and the paste of which it strongly resembles, although in some places the agglomerate in turn merges into a pebble-conglomerate with little or no well defined paste.

The ovoid masses are uniformly arranged as regards the direction of their long axes, and each one is surrounded by a sharp border, half an inch wide, of a dark greenish-grey color, which has been more resist-

ant to weathering agencies than the rest of the rock. The ovoid masses present, as the result of weathering, a rough or pimpled surface of porous aspect and bleached greenish-white colour. The interstitial filling is firmer in texture and softer than either the ovoid masses or their border, and is intermediate between them in color, with a brownish-yellow tinge.

Concretionary hornblende-schists.

In the hornblende-schists, this ovoid structure in the rock takes a somewhat different aspect, and presents the appearance of thin anastomosing sheets of dark-green, soft, chloritic material, sometimes enveloping completely ovoid or irregular-shaped portions of the hornblende-schist, and at others losing themselves in a tapering, disconnected fashion in the main mass of the rock. Fig. 6 represents a section afforded by a glaciated surface on Egg Island, in black, glistening hornblende-schists, which are in contact to the east with westerly-dipping mica-schists.

FIG. 6.—ANASTOMOSING CHLORITE VEINS IN BLACK HORNBLENDE-SCHIST.

Fragmental rocks.

A fairly typical example of the coarser varieties of these fragmental rocks is taken from the narrows between the main shore and Coney Island, near Rat Portage. It has been examined by Mr. Bayley and its microscopic characters is thus given by him.—

Microscopic characters.

"Section No. 26 is made up of broken fragments of orthoclase, plagioclase, round grains of quartz, which, between crossed nicols, seem to be made up of numerous smaller grains and fibrous hornblende in a micro-crystalline ground-mass of quartz and feldspar. Small plates of brown biotite, hornblende, little crystals of hæmatite, magnetite and apatite are disseminated all through the ground-mass.

"The structure of the rock is highly schistose, and in the schist-planes secondary green hornblende and mica are everywhere developed. Aggregates of hornblende, mica, magnetite and hæmatite occur with their longer axis parallel to the schist-planes. The fragments of

feldspar are generally fresh, but a few are decomposed with the production of sassurite. The rock is probably a conglomerate, which has undergone partial metamorphism."

Section No. 29 is that of a rock associated with micaceous schists and coarse agglomerates, occurring on the shore about two miles south-west of Wiley Point. Microscopically, it is described as "very much like No. 26. The ground-mass contains very much more secondary hornblende. The pieces of feldspar are small, and much more altered (principally into sassurite), and considerable green epidote has been developed.

"There is almost no biotite and the schistose structure is just barely evident. A little secondary calcite has been found in the interstices around the altered plagioclase."

Paste of agglomerates.

Section No. 13, from Bald Island, may be taken as representative of the paste of the agglomerate rocks so largely developed on the south side of Andrew Bay. Associated with them on the same island, in apparently conformable stratification, is the felsite described as section No. 17. The fragmental rock, as described by Mr. Bayley, "contains rounded grains and broken fragments of palgioclase, (often altered) orthoclase and quartz, held together by a mosaic cement of quartz and feldspar, most of which has become sassuritized. In this ground-mass there is considerable green fibrous hornblende and a little in well developed crystals. This may have been formed secondarily and crystallized *in situ*.

"In addition there is carbonaceous matter, leucoxene and titanic iron. Calcite in irregular grains and bleached hornblende also occur in the cement."

On the south-west side of Echo Island occurs a rock which appears to be microscopically similar to the last, although there is no marked agglomerate structure observable in it microscopically. In the field it is associated with and apparently merges into an argillite or clay-slate and is in contact with a felsitic schist.

A section of this rock, No. 14, is briefly noted as being "very similar to No. 13, except that it contains more mica and very much less hornblende. Very little feldspar occurs in broken fragments, most of which consist of clear quartz without inclusions, except in rare cases, when they are very small fluid inclusions."

Mica-schists, Micaceous slates, Clay-slates and Quartzites.

Association.

These appear to constitute on the Lake of the Woods a natural group of rocks intimately associated, both as regards their origin and their present relations in the field. Their stratigraphy and distribution will

be considered further on, but a few words may be said as to their lithological characters. The clay-slates vary from hard compact argilites to the readily cleaving blue-black slates of commerce, the one passing into the other and merging into glossy micaceous slates.

The mica-schists present considerable variations in texture and in the relative proportions of quartz and mica, entesing into their composition. A typical example has been sliced and reported on by Mr. Bayley.

Typical mica-schists.

"Section No. 2 is a mica-schist. It consists of a mosaic ground-mass of quartz grains without inclusions. Small, brown, highly pleochroic scales of biotite are arranged with their long axes parallel. Large pieces of muscovite occur in various positions without regard to the schist-planes, often crossing these, and including within themselves numerous of the smaller biotite scales and a few zicon crystals. In addition, there is scattered through the ground-mass a small quantity of epidote and calcite."

Various classes of mica-schists.

Mica-schists of this character often merge directly with agglomerate-schists in which the inclusions in the schist matrix vary but little from it in composition, and are generally lenticular in form, though not unfrequently quite irregular or abruptly angular in shape. It is not uncommon to find in these mica-schists a small proportion of feldspar, which gives them the character of finely laminated gneisses in places. As a general rule the proportion of mica in all the schists is small, and its almost total absence in many cases gives rise to quartz-schists and quartzites, which often shew a very distinct bedded arrangement. More massive quartzites of dark, greenish-gray colour occur on the south-east side of Shoal Lake, and interbedded with the felsites of the felsitic and hydromica groups of rocks, there are occasional bands of quartz rock of a flinty texture.

Glossy schist.

Sometimes mica-schists of the harsher varieties, consisting of quartz and mica, are found along the same line of strike to pass into fine-textured, glossy schists. Of these, Section No. 24 is an example, from a point on the shore of the lake two and a-half miles south of Yellow Girl Point.—

"The schist is probably a metamorphic clastic rock. It consists of a very fine-grained ground-mass, containing little plates of brown biotite and shreds of green hornblende. Throughout this micro-crystalline ground-mass are scattered irregular pieces of kaolinized feldspar, porphyritic crystals of the same mineral with beautiful zonal structure, fresh plagioclase, with twinning lamellæ, crossing at the angle of 86°, and irregularly shaped grains of limpid quartz, with club shaped intrusions of the ground-mass. The accessory minerals are apatite, pyrite, hæmatite, titanic iron and leucoxene."

Reasons for associating these rocks on map.

There exists the same difficulty of drawing hard lines between the argillites, mica-schists and quartzites, for purposes of cartography, as occurs in the case of the hornblende-schists and the various trappean rocks with which they are associated. Their characters are, in typical specimens, sufficiently distinct to make their separation on purely petrological ground an easy and desirable matter, but stratigraphically, they are so closely associated that in a field such as that of the Lake of the Woods, where exposures, though unusually good, afford access only to a fractional portion of the rock-surface, it is considered better, and more in accordance with our actual knowledge, to group these rocks under one colour.

Felsitic, Sericite, and other glossy fissile Schists of a Hydromicaceous or Chloritic character, with some Carbonaceous schists.

Association.

The petrological characters of the rocks of this natural group are in a general way conveyed by their names. A detailed account of them is, however, rendered difficult and unsatisfactory by their great susceptability to decomposition. If we except those schists which are strictly felsitic in composition, the rocks of this group are more profoundly decayed than any others in the area under consideration. The felsitic, hydromica and chloritic schists are generally intimately associated with the agglomerate rocks, into which they merge both across and along the strata, and their evenly bedded disposition leaves little doubt of their having been laid down by a process of sedimentation of some kind, the material, however, having been probably originally volcanic.

Felsitic schists.

The felsitic schists are of two general kinds, a whitish-weathering, fine-textured, compact, grey rock, usually distinctly bedded, but not particularly schistose, and a yellowish-weathering, fine-textured, very schistose rock, generally characterized by a greater or less abundance of quartz in isolated, large, clear grains of irregular shape and by a waxy lustre on the cleavage fracture. Both of these rocks merge into and become the paste of very distinct agglomerates, and these by the presence of hornblendic minerals in varying quantities blend with the green dioritic schist-agglomerate. The second or more fissile variety of these felsitic schists appears to merge on the other hand into true white, or nacreous, glossy sericite-schists of very fine, even texture.

Felsite from Labyrinth Bay.

Two of the sections of the more massive variety of these felsites have been examined by Mr. Bayley, who says of one from the south side of Labyrinth Bay :—

"Section No. 39 is very much like No. 42, except that it is more altered. The plagioclase has been almost wholly altered into sassurite, and the larger part of the orthoclase into kaolin. The decomposition has not gone quite far enough, however, to eliminate all traces of twin structure. This slide contains no mica, but a very little green hornblende and a few irregular grains of titanic iron remain, but most of it has been changed into luecoxene. This in most cases surrounds a central kernel of the titanic iron. In rare cases the original form of the crystal is preserved."

"The constituents of this rock appear to give slight indications of a schistose arrangement, but as it is impossible to decide positively as to this merely from a microscopical examination of a single slide, it has been thought best to include this rock among the felsites, where it certainly belongs if we are to be guided by microscopical structure and mineralogical composition."

Felsite from Bald Island.

"Section No. 17 (from Bald Island) is an altered felsite, very much like No. 39. It consists of a fine-grained ground-mass of clear quartz and kaolinized orthoclase, with a few larger, irregularly shaped grains of quartz, crystals of sassurite, ragged plates of light-green hornblende, a little biotite, titanic iron, surrounded by leucoxene, and needles of apatite. The whole ground-mass is filled with miciolites of muscovite."

Felsite from Big Narrows Island.

Section No. 7 is a felsitic schist of the more schistose variety from the eastern extremity of Big Narrows Island, where it constitutes the matrix of a felsitic agglomerate. It is described as "a quartz porphyry. The ground-mass of this rock is very similar to that of those noticed in Nos. 44 and 28. Instead of magnetite the rock contains pyrite, which, by its decomposition, stains the surrounding minerals a reddish-brown. Titanic iron, leucoxene, rutile in needles and yellow biotite in shreds occur. The porphyritic crystals are principally water-clear dihexahedrous of quartz. They contain inclusions of the ground-mass and very fine black dust. Many of them have been eaten into by the matrix, leaving a crystal into which has penetrated a large club-shaped portion of the crystalline ground-mass. They also contain large numbers of negative crystal-cavities containing movable bubbles. The feldspar is decomposed and very cloudy."

Serecite-schists

As a type of the sericite-schists, a specimen may be taken from a narrow band of these rocks on the south side of Tranquil Channel, lying between the agglomerate and the harsh quartzose mica-schists, which occupy the north side of Toad-stool Point. Macroscopically it is a nacreous, very fissile, glossy schist. Microscopically, "the section (No. 8) consists of a fine-grained, ground-mass of quartz, in which are plates and shreds of sericite, broken pieces of orthoclase, and plagioclase, rounded and irregularly shaped grains of limpid quartz, with liquid inclusions in lines, and considerable calcite, especially near the feldspar.

"Around the larger crystals are pressed coatings of a very light-green mica, which envelopes the crystals for about two-thirds of their periphrey. Little plates of chlorite, brown mica, hæmatite and magnetite, mingled together, mark the position held originally by some mineral from which they have been derived by decomposition.

"This rock must evidently have been originally clastic, and then have undergone metamorphism, during which the sericite and crystalline ground-mass were developed."

Carbonaceous schists.

The existence of schists of an eminently carbanaceous character in the Keewatin series of rocks, is a fact of considerable geological interest They occur in bands rarely more than 15 to 20 feet wide, in soft, very fissile, grey hydromicaceous schists, into which they merge, across the strike, by a decrease in the proportion of carbon present, till that element, as a coloring constituent of the rock at least, disappears. A mergence into the hydromica-schists *along* the line of strike has not been observed. The greatest apparent continuity that I have observed for these black carbonaceous schists, is a distance of about half a mile, on the south side of Zig-zag Point. The schists are dull black in colour, and are slaty rather than schistose, breaking sometimes with an earthy fracture, and sometimes in splintery fragments. The essential character of the schist varies from a slightly carbonaceous variety of the glossy hydromicaceous slate to a black, argillaceous slate, which soils the fingers on handling. These carbonaceous schists are characterized by two features which have never been found wanting in them wherever observed. There are (1) a well-defined vesicular structure, and (2) an abundance of pyrite. The vesicular structure is so strongly developed in some portions of the schist that it presents the appearance of a very scroiaceous slag, the vesicles ranging in size from cavities an inch or more in diameter, to those of quite minute dimensions. The great majority of these cavities are spherical in shape, and the larger ones, which offer facilities for close examination, are seen to be continuously lined with a layer of white, translucent quartz, from a thirty-second to a sixteenth of an inch in thickness. These quartz-lined cavities, when broken across the middle, are found to be perfectly empty. They appear not to have been subjected to pressure, and must consequently have been developed in the schists after the period of pressure and folding. The smaller cavities, under a quarter of an inch diameter, do not appear, as a rule, to be lined with quartz, although some are, but are very generally filled with round balls of iron pyrites, which, with a little patience, can be pricked out of the schist in handfulls. These spherules of pyrite can be seen in all stages of decomposition, from comparatively fresh, bright-yellow, hard, little balls completely filling the

Vesicular character.

cavity, to mere little aggregations of ochre in the middle of the cavities, which, in many cases, under the influence of weathering, have been removed, and left the rock with a vesicular or scoriaceous aspect. Those cavities that are perfectly lined with quartz, do not seem to have ever been filled with pyrites, for apart from the difficulty of conceiving of its removal from the cavity through the layer of compact quartz, the lining is white and smooth, and is not rusted or stained in any way, as it must inevitably have been had it ever contained a kernel of pyrite. These vesicles or cavities seem thus to have constituted moulds in which, when an impenetrable lining of quartz did not prevent it, the spherules of pyrites have been deposited from solution. In the same schists pyrites is often present in large vein-like masses of such extent as to be of prospective economic value.

Origin of vesicular character.

A satisfactory explanation of the origin of the vesicular structure in these schists is difficult to find. If the vesicles were not so perfectly round, and in many places so thickly crowded together, we might resort to the ordinary explanation of the solution and removal of some mineral contained in the schist, whereby cavities were formed. The perfectly spherical shape of many of the cavitees and their eminently scoriaceous aspect, irresistably suggest the agency of a confined gas or vapor acting upon a more or less yielding mass as concerned in the development of this curious structure.

Microscopic character.

Little seems to be gathered as to the history of the rock from its microscopic characters. An examination (Section No. 46), shews it to "consist principally of carbonaceous material, in grains and irregular masses, arranged to some degree parallel to the schist-planes. The other constituent is quartz, in grains, and here and there in little mosaics."

An analysis of a specimen of this schist by Mr. Frank Adams shewed it to contain 5·773 per cent. of carbonaceous matter.

The presence of this carbonaceous matter in schists, which form part of a group of rocks, regarded by littrologists as altered sediments, is of the greatest possible interest in its bearing upon the question of the earliest appearance of processes of elimination of carbon in the free state at the surface of the earth.

Limestones.

Occur generally as vein-stones.

The few dolomitic limestones that are found upon the Lake of the Woods seem to be of the nature of vein-stones, rather than bedded strata. No deposits of any considerable extent were observed, the largest being not more than twenty feet in thickness. The more fissile and decomposed portions of the hydromicaceous and chloritic group of

schists are characterized by the presence of numerous lenticular or stringer-like segregations of yellowish crystalline dolomite. These stringers are for the most part parallel with the cleavage-planes of the schist, and by their stronger development in certain places pass into veins, which are sometimes mere accumulations of these stringers in parallel juxtaposition, and at others form solid masses of dolomite several feet in thickness. In this respect they are similar in their behavior to quartz stringers, found under similar conditions in the same rocks. These dolomite veins have been formed generally in fissures striking with the schists, but in some cases they cross the strike. On the north-east end of Scotty Island a very good instance is seen of a dolomite vein, several inches in breadth, branching out from a large mass, apparently interbedded with the schists, and crossing the strike of the latter in a zig-zag course, filling an irregular transverse fissure. There is no reason to doubt but that the large deposits of dolomite of identical minearlogical characters and texture, which, from the size, have more the appearance of bedded masses, are also veins. When these larger deposits of yellowish dolomite occur in fissile hydromica-schists, the latter are characterized on either side of the main mass by small stringers of the same dolomite, often mixed with quartz, holding radiating bunches of tourmaline needles. These larger veins do not resemble stratified beds in being continuous across country for considerable distances. They seem, on the contrary, to be of very limited extent, those found, as sometimes happens, in approximately the same strike at widely separated intervals, being simply parallel segregations along a general line of veining.

General character.

These dolomites present in their weathered aspect a deep incrustation of ochre. In composition, they are often extremely silicious, the silica taking the form of a network of quartz stringers, which traverse the dolomite in all directions and stand out as prominent ridges upon its weathered surface. Cubes of pyrite and octahedra of magnetite are the only other minerals macroscopically observable in these dolomites. An analysis of a quartz-free specimen, given elsewhere, shows it to be nearly pure dolomite.

Green dolomite

Besides these yellowish dolomites, varieties of different color and texture occur, also as veins. An interesting green dolomite was found in fissile green schists on a small island between Pine Point and Heenan Point. A section of it (No. 9), under the microscope, is described as "consisting almost entirely of dolomite, whieh is in irregular grains, with beautiful cleavage lines running through them. In addition to these are little mosaics of quartz grains and considerable colourless hornblende. Some irregular patches of ocherous substance also occur, as if they were the remains of original pyrite crystals. This

rock, at first sight, resembles an eclogite, and appears to be composed largely of smaragdite. It is, however, almost all a carbonate."

Pink dolomite.

A little to the north of the entrance to Ptarmigan Bay a narrow vein-like band, about two feet thick, was observed, of a beautiful, pink, soft, saccharoidal marble, in dark green schists.

On the north shore of Shoal Lake a calcareous rock of undetermined extent was observed and was supposed in the field to be a limestone; a more careful examination of it, however, shews that it can scarcely be so called. Analysis shews that it only contains 40 per cent. of carbonate of lime and magnesia. Its microscopic characters are as follows.—

"Section No. 40.—This rock consists of a ground-mass of quartz and an isotropic substance, with all the characteristics of Rosenbusch's 'felsitic ground-mass.' With this is mingled a quantity of calcite. Muscovite in shreds extends throughout it, and, besides, there are in it numerous crystals of rutile, some of which are twinned according to the ordinary law, giving rise to elbow-shaped particles. Aggregates of a dark-green mineral, slightly pleochroic, probably epidote, and a gray, cloudy substance complete the minerals in this rock.

"In order to place this rock in its proper classification, a much more thorough study of it is necessary than there is opportunity for. It seems to be a sort of calcareous metamorphic slate."

LIMITS OF AREA OF THE KEEWATIN (HURONIAN) ROCKS.—CONDITIONS OF CONTACT WITH SURROUNDING GRANITOID GNEISSES.

General outlines of Keewatin area.

The Keewatin or so-called Huronian rocks, mapped on the sheet accompanying this report, occupies an area having the shape of a rhomboidal parallelogram, which presents the appearance of an almost isolated patch, surrounded by massive granitoid Laurentian gneisses* on every side. The area, as a whole, will be found when its geological structure comes to be considered, to have the characters of a sharply folded basin within which a great thickness of local deposition of peculiar rocks has taken place. The axis of folding of this basin is nowhere a straight line, but is flexuous. For purposes of description, however, it may be considered as approximately straight, and be said to intersect the meridian with a bearing of about N. 80° E.

* As stated on a previous page of this report (P. 50 CC.), the gneisses observed within the region described are all granitoid in character and often very coarse. They are, therefore, not strictly comparable with the more schistose and presumably newer Laurentian rocks which constitute the so-called Middle Laurentian, and which are found to rest upon granitoid gneisses like those above referred to, in other parts of Canada.—D.

To this axis of flexure the north and south limits of the area, i. e., the two greater sides of the rhomboid, are parallel, and it corresponds in a general way with the average strike of the schists which are embraced within it. The east and west limits of the area, or the shorter sides of the rhomboid, are not so uniform in direction as the north and south limits. They are formed to a large extent by the rather abruptly terminating folds of the Keewatin strata. It is an interesting fact that, while the greater portion of the strata strike E. N. E. and W. S. W., this is not the direction of the long, but of the short diagonal of the rhomboid, and that the long diagonal corresponds approximately with a line of intrusive granite masses running from W. N. W. to E. S. E.

Line of junction as shown on map.

It is desirable first to describe as accurately as possible the course of the boundary of this area, or the line of demarkation between its rocks and those of the Laurentian, in order that there may be a clear understanding as to what portion of the line, as mapped, is observed fact, and what portion of it is, as is unavoidable in nearly all geological field work, conjectural.

Junction at Rat Portage.

We may begin where the line is easiest of access, viz., at Hebe's Falls, near Rat Portage. Here, about a chain or so below the falls, at the lower end of the gorge through which the Lake of the Woods pours its waters into the Winnipeg River, the contact of the granitoid gneiss and Keewatin schists is seen, the dividing line having a strike of about N. 80° E. The lamination of the schists on one side of the line of contact and the foliation of the gneiss on the other, have a strike coincident in drection with it. The dip of both rocks is to the north at an angle of about 65° the schist passing beneath the gneiss. On the assumption that gneissic foliation is a proof of aqueous sedimentation, a cursory examination of the section showing the contact might lead an observer to decide that it was simply the conformable contact of two series of rock, of which the gneiss was superimposed upon the hornblende-schists. Another more careful glance at the conditions presented in the section would show him that there was no single, simple plane of contact between the two series, although the strike and dip were the same. Bands of gneiss are seen to be apparently interbedded with the schist, and on the supposition of a conformable contact there would seem to be alternating beds, making a transitional passage from one series to the other. Such was the explanation that presented itself to me when first I visited the section. A subsequent more critical scrutiny of the facts revealed in the section, however, rendered it impossible for me to consider these bands of gneiss mixed with the hornblende-schist as an alternating sequence of transitional beds. By the light of observations made on the contact of the two

Apparent interbedding.

series of rocks elsewhere, and a closer examination of their relations to each other here, it was found that a very different explanation of that relationship was not only possible, but highly probable. The bands of gneiss have rather the characters of igneous injections than beds. They are generally parallel with the lamination of the schist because the lines of lamination are the lines of weakness in the rock along which such injections would most easily find their way. The bands are short and their continuity interrupted. They either taper rapidly to a point or end abruptly upon the broken edge of a band of schist forming a kind of breccia, which, however, is more characteristically developed in similar exposures of the contact to be described further on.

Jointage.

The gneisses seem to have been in a plastic condition at a date subsequent to that at which the hornblende-schists had assumed a hard and brittle state. Both the gneiss and hornblende-schist are jointed but in different directions. To the north of the contact the gneiss presents a very well defined system of jointing, the planes of which are coincident with the planes of foliation the gneiss, *i.e.*, sloping to the north at high angles. In the hornblende-schists to the south of the contact, on the other hand, the jointing slopes to the south-west at low and rather inconstant angles. The gneiss is a distinctly foliated porphyroid rock, having a grey matrix of quartz and mica, in which are imbedded large, light, flesh-tinted crystals of orthoclase, which are often rounded in form, with a flowed structure, evidenced by the arrangement of the mica, conforming to their outline. The hornblende-schist is of dark-green to geeenish-black in color, evenly cleaved, and rather hard, but merging in places into softer varieties of lighter colour, and somewhat micaceous in composition.

Character of rocks at junction.

Line of junction traced westward.

The contact is seen on the east side of the gorge at the falls. From there the line runs beneath the bay of the river, which lies just to the west of the gorge, and the two rocks are seen a few yards apart on either side of the line of junction at the bottom of the bay, although the actual contact is concealed by a deposit of sand. From here the line may be traced, with comparative closeness, across Tunnel Island, without change in the dip or strike, to the second outlet of the lake below the Witch's Cauldron.

On the portage-path along the river at this point, the gneiss holds in places large and small angular fragments of the hornblende-schist. The line of junction crosses the river about eighteen or twenty chains to the north of the railway bridge, and, following the ridge which separates the waters of the lake from Darlington Bay, is next seen, over a mile to the west, near Keewatin station and still on the north side of the railway. A little further west the junction is again seen on the

At Darlington Bay.

shores of Darlington Bay, just below the water tank of the railway yard. The common strike of the gneiss and schist is here, as before, about N. 80° E., and the dip north. In a general way the planes of lamination of the schist and foliation of the gneiss are parallel, though here, as at the contact first described, there are unmistakable evidences that the contact is an igneous one, and that when there is a mixed alteration of gneiss and schist the former has been injected, within the latter. This mixture of gneiss and schist, with occasional short broken bands and fragments of schist included within the gneiss, occur at intervals along the shore of Darlington Bay, to the railway bank which dams up the mouth of Mink Bay.

Mixture of gneiss and schist.

In some of these injected portions of the gneiss the mica is much less in quantity than usual, and the rock presents the character of a reddish mixture of quartz and feldspar with porphyritic crystals of the latter. In others the mica is quite visible, and gives the rock its characteristic gneissic structure, the foliation abutting upon the sharp or ragged edges of schist.

Darlington Bay to War-eagle Lake.

Half a mile farther west the gneiss just forms the edge of the south shore, and the line of contact has again a strike of N. 80° E. Beyond this in the line of junction crosses to the other side of the bay, still running in the same direction, and is again seen on both sides of the mouth of the northern extension of Darlington Bay, known as Middle Lake, the rocks having the same common dip and strike. The line of junction when next seen crosses the railway-track, about fifty chains westward of the trestle bridge at the bottom of Darlington Bay. From this point westward, the line of junction bends a little more to the south, for when next exposed, further on at the end of War-eagle Lake, the strike of the gneiss and schist is about N. 70° E., the dip as usual being to the north. War-eagle Lake has been hollowed out of the rocks along the line in question, for the line skirts the south shore of the lake with a strike varying from N. 60° E. to N. 70° E., the prominent points of the shore being tipped with gneiss, while the greater intervening portions expose northerly-dipping schists. The north side of the lake is all gneiss. From the west end of War-eagle Lake the line of junction bends against the north, and assuming a nearly east-and-west course, is next observed where intersected by the old cart-trail from the now abandoned Argyle mine to Deception. Between these points not only has the strike bent around considerably from its former course, but the plane of the dip has suffered a tortion, so that whereas it was at War-eagle Lake to the north, the schist passing under the gneiss, it is now to the south, and the actual relative position of the two formations is reversed. The structure is analagous to that of the surface of the whorl of a screw augur, if the edge of the spiral be regarded as corresponding to the

strike. The bend of the rocks is at the point mentioned, about S. 70° E. Dip south $<70^\circ$.

Junction at Rice Lake.

Half a mile farther west the junction is again seen near to the east end of Rice Lake with the same strike of S. 70° E., and south dip common to both rocks. This reversal of the dip since it was last noticed on War-eagle Lake is associated in its course with an abnormal condition of the rocks, which is peculiarly interesting in its bearing upon the relationship of the hornblende-schists of the Keewatin to the granitoid gneiss. A glance at the map will show the disposition of the two kinds of rock at this junction in the line of contact we are now considering. The gneiss and schist appear to be wedged into each other in a way that is difficult to account for simply by folding. The schists that have been described as being in contact with the gneiss with a strike of S. 70° E. and southerly dip, on the Argyle mine road and at the end of Rice Lake, form a sharp tongue which seems to taper off rapidly at the west end of Rice Lake.

Tongue of schist at Rice Lake.

This tongue of schist has a breadth of half a mile at the east end of Rice Lake, from where it is first met with, on the portage path from Clear-water Bay to Rice Lake, to where it is again seen in contact with the gneiss at the north-east corner of that lake. The dip of the hornblende-schist across this breadth is continuously to the south, at angles varying from 70° to 65°, and the strike ranges from S. 85° E. on the south side to S. 70° E. on the north. At the west end of Rice Lake it has a breadth of about fifteen chains, strike S. 70° E., dip south. Beyond this it does not appear to continue much farther. To the south of this tongue of schist, the granitoid gneiss, under which it dips, has a breadth on the portage path of about half a mile, to the shores of Clear-water Bay, where it immediately again comes in contact with black hornblende-schists to the south. These hornblende schists are precisely similar to those on Rice Lake, but dip in the opposite direction, to the north, so that they also appear to run under the gneiss and constitute with the latter a basin in which the gneiss lies. The hornblende-schists found at the south end of the portage path and on the shores of Clear-water Bay to the east of it also form a rather abruptly ending tongue. As the convergence of the strike of these two enclosing tongues of schist would indicate, they merge into each other at no great distance to the east, for on the Argyle mine road the gneiss is not seen to extend that far east, the rocks in a fairly continuous series of exposures being all black hornblende-schists. Along this line of section the attitude of the hornblende-schists gradually changes from a northerly dip at the south, to a vertical position and then to a southerly dip as the contact with gneiss on the north is approached. This would again point to a synclinal structure, in the trough of which lies the gneiss crossed by the Rice Lake Portage.

Difficulties in explaining stratigraphical relations.

The explanation is not, however, so simple as it would appear. If we were in a position to state definitely and without doubt that the granitoid gneiss is a sedimentary rock, then the facts which have been adduced point clearly to the explanation that the gneiss is now superimposed, and was originally superimposed, upon the hornblende-schist as a later formation. But we cannot assert that the granitoid gneiss is of sedimentary origin, and if we could, the explanation we would then be forced to adopt would involve us in the absurdity of the statement that one sedimentary series is at once above and below another, since this same granitoid gneiss is everywhere assumed to be stratigraphically inferior to the schist. There are other considerations which point to a totally different and more consistent explanation of the structure in question.

Abrupt termination of tongues of schist.

It will be seen by the map that the gneiss included between the two abruptly-ending tongues of inward-dipping schists occupies the shores of Clear-water Bay for a mile or more to the west of the portage path where it is first met with. It constitutes the rock in which Granite Lake lies and is continuous with the great area of Laurentian gneiss to the north. The whole breadth of the hornblende-schists coming from the east is very abruptly interrupted by this mass of gneiss, which is thus brought in contact with the next higher group of rocks the mica-schists and micaceous schist-agglomerates, which are exposed so extensively on the north shore of Clear-water Bay. The strike of the hornblende-schists, particularly that of the southern of the two tongues into which it bifurcates, appear to butt directly upon this interrupting mass of gneiss as upon an intrusion. The hornblende-schists would thus appear to have been at this place upheaved above the level that has escaped subsequent denudation, and their place occupied by the gneiss which has been squeezed up from below. Other facts also point to the probability of this being the true condition of things. The line of contact of the gneiss and schist, wherever it can be observed, is unmistakably an igneous one, the gneiss being in places injected through the schist in dykes and at others being a breccia in which the gneiss forms a matrix for the broken angular fragments of the schist.

Circumstances showing plasticity of gneiss subsequent to induration of Keewatin rocks

At the extreme west end of the portion of Clear-water Bay, which leads up to the portage, the hornblende-schists having been entirely removed, the gneiss is in contact with a mica-schist, which presents a feebly agglomeritic aspect in places, and breaks through it in irregular dyke-like injections, ranging in width from a few inches to several feet. The same thing is seen again near the portage, on the south side of the point of land that separates the waters of the bay from the creek that runs into it. Here the rocks are very much mixed, and the injected portions of the gneiss are more granitic in their texture and

of a redder color, the feldspar being the dominant constituent. Along the line of the contact to the south of Rice Lake, the planes of the foliation of the gneiss and of the lamination of the schist are quite parallel, and these appear to be an alternating transitional series of beds of gneiss and schist, but the gneiss is simply injected in the form of sheets along the lamination of the schist, and in places cuts them transversely. The gneiss also forms the matrix of a clearly-defined breccia, which can be traced for over a quarter of a mile to the north of the line of contact on the rounded surface of the bare, well-exposed rocks. The angular blocks vary considerably in size, but would probably have an average sectional area of about a couple of square feet. In some instances there is a flowed structure in the gneiss, conforming roughly with the outline of the included block. At other times the foliation abuts squarely upon its edge. These conditions admit of only one explanation, which, so far as it goes, seems to be true beyond dispute, viz : that the gneiss, let its foliated structure be explained as best it may, was in a plastic or viscid state at a time subsequent to the hornblende-rock having become hard, brittle, and capable of being broken off into the numerous fragments that are now found in the breccia along the line of contact. The existence of a distinctly foliated and even banded structure in the matrix of such a breccia demonstrates how altogether unnecessary it is to look for an explanation in a theory of aqueous sedimentation. The foliation has undoubtedly been developed in it at a period subsequent to its having been in a viscid or liquid condition, as not only these instances, but others, to be adduced farther on, prove.

Tongue of schist wedged apart by intrusive mass.

The bifurcation of the abruptly-ending belt of hornblende-schists, is such as might be looked for as a result of the upward protrusion of a great mass of molten rock. And although the schists in either spur of this bifurcation dip toward the central mass rather than away from it, as might be expected, this is not incompatible with the belief that the bifurcation is due to an igneous intrusion. The dipping of the schists in opposite directions towards each other does not necessarily imply a synclinal structure. From all that can be observed of the belt of hornblende-schists its breadth, as traversed by the Argyle mine road, from where it is in contact to the south with the agglomerate-schists to its junction with the gneiss on the north, is the natural thickness of the formations after correction has been made for the inclination of the rocks. This being the case, there is no true synclinal structure, only an apparent one, the nearly vertical schists having been wedged assunder by the rending force of the intrusion into two dividing tongues, the southern of which has been bent throngh an angle of more than 90°, so as to appear to dip northward at the plane of the present surface.

Junction on Clear-water Bay.

West of the point, on the shores of Clear-water Bay, where the granitoid gneiss is seen in contact with the micaceous schists, the line of junction, which here has a strike of about N. 70° E., curves around more to the south, and is seen on the south-west side of Granite Lake, with a strike of S. 70° E., the schists running around as if to embrace this mass of gneiss, much as they do around the Yellow Girl granite mass. The dip is N. < 75 on Granite Lake.

Line of junction further west.

Beyond this the character of the country is such that the line of junction has been traced out much less satisfactorily than the portion of it described. The line is next seen where it is crossed by the portage road from Indian Bay to High Lake, at a point about an eighth of a mile to the south of the falls by which the lake is drained. The rock in contact with the gneiss is a dark-green schistose hornblende-rock, and the gneiss itself is very granitoid in texture, a gneissic foliation being scarsely discernible in some portions of it, although in others it is sufficiently well marked. The strike is N. 80° E., and dip to the north. Four and a-half miles further west the junction crosses the Falcon River with a strike of N. 67° E., and northerly dip common to both rocks, although the actual contact is not exposed. The gneiss here is almost identical with that seen at Hebe's Falls, near Rat Portage, but perhaps a little coarser in texture.

West of the Falcon River the country sinks in level, and there is little or no access into it, so that it has been found impracticable to trace out farther in this direction the junction of the gneiss and schist.

Western termination of Keewatin rocks

The character of the western boundary of the area is inferred very largely from the conditions that are presented for examination on the shores from the Falcon River to the south end of Shoal Lake and at the mouth of the North-west Angle Inlet. The rocks on the west side of Shoal Lake are almost continuously exposed. From the junction of the gneiss and schists, on the Falcon River, there is a breadth across the strike of three miles of Keewatin rocks, chiefly schistose hornblendic, dioritic and diabasic rocks, with some bands of mica-schist, to where the gneiss is again found in contact with them to the south. This distance measures the breadth of a tongue of these rocks of the character of a folded trough, which, from the convergence of the strike, terminates at probably no great distance west of the end of Indian Bay in the great area of encircling gneiss to the west, which is well exposed on Snow-shoe and Rice Bays and on the shore of Shoal Lake.

The southern line of junction of this tongue of schists, with the gneiss, runs along the middle of the narrow peninsula that separates Indian and Snow-shoe Bays. Southward from the mouth of Snow-shoe Bay there is a continuous exposure of granitoid gneiss for a breadth of

three and a-half miles. To the north of this lies a green volcanic agglomerate rock, passing into a schistose hornblende-rock. To the south of the gneiss a group of schists, chiefly quartzose and micaceous and occasionally hornblendic in character, is crossed. The dips of both these rocks near the contact is south, and the strike is approximately south-west, but bends more and more to the north as the strata are crossed going north from the junction. The dip and strike of the rocks between this junction and the south end of the lake points to a synclinal structure, and as these rocks have not been found to cross the Dawson road to the south in the direction of their strike, it is conjectured, in the absence of proofs, due to the low swampy character of the country, that the strata terminate in some such fashion as is represented. The rock along the Dawson road, wherever it is possible to observe it, is a coarse gneiss.* On the east side of the south end of Shoal Lake a group of schists, similar to those in contact with the gneiss on the west side, is seen lying to the east of a gray granitoid gneiss. The dip of these rocks is away from the gneiss to the eastward. They are chiefly micaceous quartose schists of a gnessic structure, with often a considerable proportion of hornblende in some layers. A similar group of rocks is seen at the mouth of the Northwest Angle Inlet. These also dip away from the gneiss, but towards the north so as to form a synclinal fold with those of Shoal Lake. The strike, like the dip, converges, so that the projections of that on Shoal Lake and on the shore of the inlet would meet at a point near the North-west Angle. The only rock seen in that neighborhood is that recorded by Dr. G. M. Dawson† as a "dark gneissic rock," which "holds apparently both hornblende and mica, which are arranged in thin and regular laminæ, and is nearly vertical with a strike of N. 70° E." (Mag.) and "compact greyish-black micaceous rock." Both of these rocks, I should judge from their description, belong to the group of rocks forming the synclinal trough, whose outer flanks are revealed on the east shore of Shoal Lake to the north and at the mouth of the North-west Angle Inlet to the south. This would locate the end of the trough somewhere to the west of the North-west Point, though from the nature of the country the actual course of the geological line I have endeavored to trace out, must always here be a matter of conjecture, and the mapping simply represent what is considered the most probable condition of the rocks, from the facts available for observation.

Exposures on Dawson Road.

Rocks near the North-west Angle.

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* Dr. Bell reports that he "found Laurentian gneiss exposed at intervals along the road to Red River, for about thirty miles westward of the Government station at the North-west Angle." Report of Progress Geol. Survey of Canada, 1872-73, p. 104.

† Geology and Resources of the Forty-ninth Parallel, p. 25.

North-west Angle to Falcon Island.

Between the mouth of the North-west Angle Inlet and the north end of Falcon Island the nature of the contact of the two series of rocks can only be partially examined, the greater space being occupied by the waters of the lake. So far as can be gathered from the intervening islands, there is much less distinctness and precision in the line of contact displayed here than anywhere else in the boundaries of the Keewatin area. Passing eastward, the mica- and hornblende-schists of the shore to the north of the inlet assume more and more an agglomerate structure and merge towards the gneiss into a quite feldspathic 'agglomerate gneiss,' which in turn, by a gradual obliteration of the agglomerate structure, seems to pass into granitoid gneiss, so as to render it extremely difficult to draw any sharp line of demarkation between them. On the north shore of Falcon Island and on the northern border of the Grande Presqu'île, however, the line of contact once more resumes that precision and definiteness of character, which marks it, to the west of Rat Portage, and becomes a simple, sharp line between a black hornblende-schist and a coarse-textured granitoid gneiss.

Junction at Falcon Island.

The line of contact of the Keewatin and Laurentian, as it crosses Falcon Island, at no great distance from the north shore, forms a distinct curve, striking first to the east-north-east, then east, then bending rather sharply to the south-east. At the western extremity of the north end of Falcon Island, a considerable thickness of 'agglomerate gneiss' occupies a position between the hornblende-schist and the granitoid gneiss, although the contact of the latter with the agglomerate cannot be made out definitely. To the eastward this 'agglomerate gneiss' seems to thin out rapidly, leaving the hornblende-schist and granitoid gneiss in close contact. A sharp, pinched off infold of the hornblende-schists, produces a V-shaped digression to the southward in the line of junction, at the east side of the north end of Falcon Island. This sudden southward projection of the schists within the area of the gneiss, so suggestively indicative of a folding transverse in the direction of its action to that of the ordinary plications of the region, is almost directly opposite, (across the strike of the rocks,) to the abnormal break in the continuity of the line of junction noticed at Clear-water Bay, on the northern limits of the area. The apex of the V is naturally continued in the belt of black hornblende-schist that seems to lie in the bed of the Tug Channel, and forms the connecting link between the hornblende-schists of the neighborhood of French Portage and the area to the north, and these bands of schist, represented on the map as occupying the southern portion of Falcon Island, and skirting the southern shores of the Grande Presqu'île.

V-shaped fold.

The apex of the V is two and three-quarter miles south of French Portage, and its return sweep to the north passes to the east of that point only a few dozen yards, the contact being seen on the ridge between the portage and the marsh to the east of it.

Contorted rocks

Whenever the contact of the schist and gneiss can be observed along the outline of this V, there is the usual parallelism between the planes of lamination of the schist and those of the foliation of the gneiss. The strata here have been subjected to unusually violent tortions, and at distances not great from the actual contact, the strikes of the two rocks are sometimes discordant, but they invariably curve around into parallelism, whenever the actual contact is exposed. Coupled with this parallelism of strike and dip, however, are also the phenomena of the injection of the gneiss within the schist. This is very characteristically seen in the patch of schist that outcrops on the west shore of the Tug Channel, a little over a mile and a-half to the south of the apex of the V.

North side of Grande Presq'île.

Beyond French Portage the line of junction bends round so as to have more of an easterly trend, and within the next six miles there are three excellent sections showing the contact, afforded by Beaver Inlet, Astron Bay and Maud Lake, long, narrow sheets of water extending southward from the main body of the lake into the Grande Presqu'île. The line crosses these bodies of water close to their entrance into the main lake. The strike of schist and gneiss at French Portage is about N. 45° E.; at the mouth of Beaver Inlet it is N. 65° E.; at the mouth of Astron Bay it is N. 70° E.; and at the foot of the little cascade by which Maud Lake is emptied it is N. 75° E., the dip throughout being to the north at angles from 60° to 65° and 70°, so that the gneiss passes beneath the schist.

Junction along west shore of White-fish Bay

At the mouths of Beaver Inlet and Astron Bay the contact of the two rocks is clearly exposed, and dykes of the gneiss are seen penetrating the schist parallel, for the most part, to its lamination. At the outlet of Maud Lake the contact is not observable, although the two rocks are seen a few yards apart from each other. All the rest of the shores of Beaver Inlet, Astron Bay and Maud Lake, to the southward of the contact, are composed of reddish, granitoid gneisses.

The next point to the east where the line of contact is intersected is at the bottom of the most north-westerly arm of White-fish Bay, five miles west of Rendezvous Point, where the common strike is S. 55° E. and the dip N. $<$ 75°. There are here to the north of the contact, sheets of gneiss parallel to the lamination of the schists, which are probably injected from the main mass of gneiss as has been found to be the case elsewhere. Beyond this the line of junction assumes an east-south-easterly trend and is next exposed on the shore of White-fish Bay about

a mile and a-half south-west of Rendezvous Point. Thence it crosses the small islands lying in the White-fish Bay Passage, known as the East and West Pointers, with a more easterly strike, the junction of schist and gneiss being again exposed in a little bay on the extremity of Long Point, at a place almost due east of the exposure to the south-west of Rendezvous Point. To the south-eastward of this the strike of the line of contact and the trend of the shore of White-fish Bay are for a long distance practically coincident, as will be gathered from a glance at the map. From the extremity of Long Point the strike of the rocks carries the line of junction inland for some distance, but it soon curves rapidly to the southward. On the north side of Long Bay its course is seen to be interrupted by a mass of red granite evidently intrusive through both gneiss and schist, but on the south side of the bay the gneiss and schist are again seen in contact, with a common strike of S. 30° E., and a north-easterly dip at high angles. About a mile farther on the line is again exposed on the south-west side of Long Point with the same trend of S. 30° E. and northerly dip of the strata.

Junction along east shore of White-fish Bay

From this point the line of junction runs south-eastward across Fire Island, the north side of which is occupied by schist and the south side by gneiss. It is next seen skirting the east shore of White-fish Bay, the gneiss tipping the prominent headlands such as Return Point, White Point, Cat Point and Paddle Point, while the intervening stretches of shore expose black or dark-green hornblendic schistose rocks with occasional bands of mica-schist. The strike at Fire Island is about S. 30° E., but at Sioux Point and towards Return Point it curves around to S. 40° E. and then to S. 50° E., the dip throughout remaining for the most part to the north-east or vertical; though in places reversed. The line of junction all along this north and north-east shore of White-fish Bay is a brecciated one. Wherever a section of the rocks showing the contact is observable the gneiss is seen to have been injected or protruded within the schists, and to contain irregular fragments of the latter at varying distances from the contact of the two rocks, although their planes of lamination present a well-marked parallelism on either side of that contact. Along the shore which cuts the strike of the rocks to the south-west of Rendezvous Point numerous dykes of gneiss cut the schists, both as apparently evenly intercalated beds, and as irregular and intrusive masses.

Details of junction, mouth of White-fish Bay.

As the great gneissic area to the south is approached these become more numerous. The junction itself is exposed on this shore on the face of a low cliff presenting the appearance figured in the annexed diagram, there being apparently no sharply defined line of contact, but a transitional series of layers of alternate gneiss and schist. These bed-

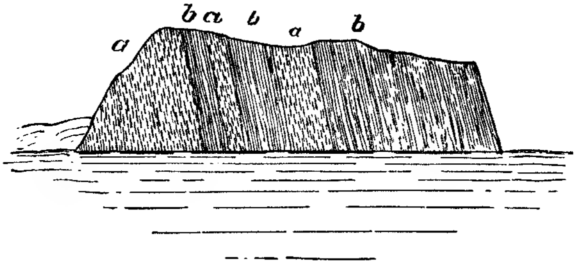


Fig. 7.— *a*. Granitoid gneiss. *b*. Hornblende-schist. The two rocks apparently interbedded as a transitional alteration, but the gneiss in reality intruded within the schists. Scale 1 inch = 20 feet.

like sheets of gneiss within the schist, however, are injected as may be gathered from an examination of the same line of junction on the islands a little to the east. The accompanying diagram, (Fig. 8,) illustrates the junction on an island known as the West Pointer, near the mouth of the White-fish Bay.

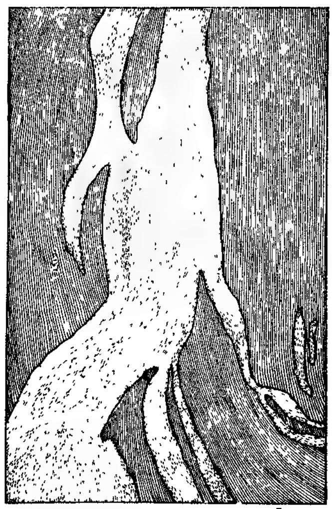
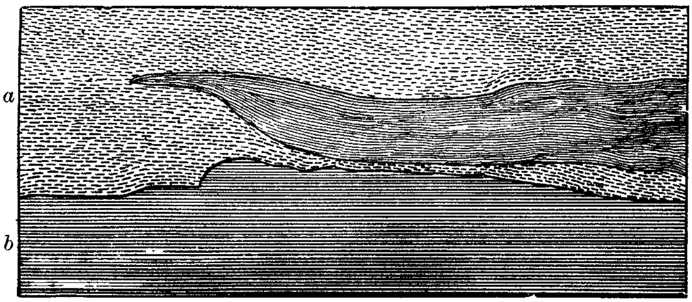


Fig. 8.—Gneiss injected within hornblende-schists in immediate vicinity of contact of the two formations. *a*. Gneiss, *b*. Hornblende-schist. Scale 1 inch = 5 feet.

The northern portion of the island is occupied by greenish-black hornblende-schists, and the southern by coarse-textured gneiss. About the middle of the island the irregular intrusion of gneiss, shown in the

figure, breaks through the hornblende-schists. The intruded rock resembles closely the regular gneiss to the south of the contact, and its foliated character is quite as well defined. The irregular nature of the fissure through which the gneiss has been injected is such that it cuts across the schists at some places and runs with the strike in others. The foliation of the contained gneiss is approximately parallel to the walls of the fissure. In one place this foliation and the general run of the dyke have a common strike of N. 45° W., while the schists which abut sharply on the dyke, have a strike due east. The intrusion is beyond question identical with the great mass of granitoid gneiss to the south, and the conditions of its occurrence afford a striking proof

Evidence of plasticity of gneiss.



Section illustrating alternations o gneiss and schist.

Fig. 9.—Contact of gneiss and hornblende-schist. Island in the White-fish Bay Passage. *a.* Gneiss. *b.* Hornblende-schist. Scale, 1 inch = 4 feet.

of the plastic condition in which these rocks must once have been either as an original state, or as induced at the time of folding The belief that this intrusion constitutes a part of the granitoid gneiss is borne out, not only by the similarity of the rocks, but also by the nature of the contact a few yards to the south. An instance of the appearance presented along this contact is shown in Fig. 9, in which the gneiss, which behaves as an injection, is in actual continuity with the great area of gneiss to the south of the contact.

On the shore of White-fish Bay, at Return Point, a little below the Sioux Narrows, an excellent section is exposed shewing the mixed character of the contact of the gneiss and schist. On the north side of the point is a great thickness of hornblende-schists, while to the south lies the great area of the White-fish Bay gneisses. The intervening or prominent portion of the point is occupied by the following alternation of bands of gneiss and schist, the strike of the rocks being S. 50° E., and the dip either vertical or at very high angles to the south:—

1.	Gneiss	1	foot	7	inches.
2.	Hornblende-schist	54	feet.		
3.	Gneiss	11	"		
4.	Hornblende-schist	60	"		
5.	Gneiss	3	"	8	"
6.	Hornblene-schist	31	"		
7.	Gneiss	1		8	"
8.	Hornblende-schist	11	"		
9.	Gneiss	20	"		
10.	Horblende-schist	22	"	7	"
11.	Gneiss	0		8	"
12.	Hornblende-schist	58	"		
13.	Gneiss	4		4	"
14.	Hornblende-schist	6	"		
15.	Gneiss	0	"	6	"
16.	Hornblende-schist	32	"		
17.	Gneiss	12	"	2	"
18.	Hornblende-schist	13	"		
19.	Gneiss	1	"	8	"
20.	Hornblende-schist	4	"		
21.	Gneiss	3	"		
22.	Hornblende-schist	1	"	3	"
23.	Gneiss	1	"	6	"
24.	Hornblende-schist	5	"		
25.	Gneiss	0	"	4	"
26.	Hornblende-schist	0	"	8	"
27.	Gneiss	1	"		
28.	Hornblende-schist	1	"		
29.	Gneiss	2	"	8	"
30.	Hornblende-schist	5	"		
31.	Gneiss	100	"		
32.	Hornblende-schist	12	"		
33.	Mixed gneiss and schist	20	"		
	Gneiss indefinite thickness.				

These bands of gneiss alternating with the schist are for the most part regular and bed-like in their characters, but their true nature as injected sheets or dykes is sufficiently revealed.

Ragged edges of hornblende-schist.

That marked No. 9 is less regular than the others and penetrates the containing schist in irregular tongues. No. 21 is also very irregular and includes fragments of the schist walls. No. 23 is quite irregular in its thickness and does not resemble an interstratified bed. No. 29, though quite distinctly foliated, penetrates the schist and holds within it slender, wedge-shaped bands of schist. The last twenty feet of this alternating series of bands is very brecciated in its character, the gneiss penetrating the schist in every direction and holding angular blocks of it. Fig. 10 shows a vertical section of a broken and ragged edge of hornblende-schist that has been enclosed by the gneiss.

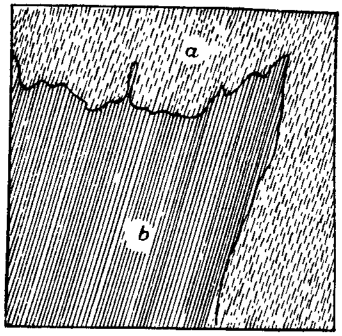


Fig. 10.—Vertical section showing angular corner of hornblende-schist included within gneiss, *a*. Gneiss, *b*. Hornblende-schist. Scale 1 inch = 4 feet.

Irregular intrusion of gneissic rock.

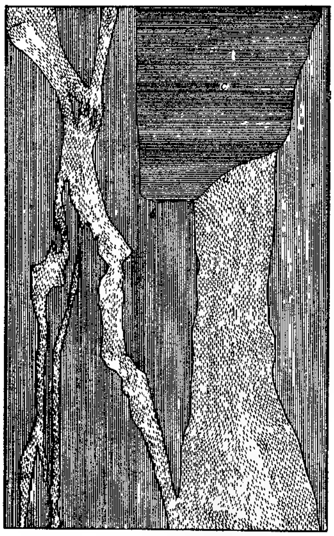


Fig. 11.—Horizontal section showing gneiss injected within hornblende-schist on shore of White-fish Bay south of Sioux Narrows.

a. Gneiss.

b. Hornblende-schist.

c. Unexposed.

Scale, 1 inch = 2 feet.

Fig. 11 shows the ground plan or horizontal section of another instance of the irregular intrusion of well foliated gneiss within the schists. The schists have a uniform strike of S. 50° E., and often abut obliquely upon the walls of the gneiss, to which the foliation of the latter is for the most part parallel. To the south-east of Return Point the strata bend around to S. 20° E., and the dip is decidedly to the north-east, being on Cat Point at as low an angle as 45°. After crossing the mouth of Snake Bay, the line of junction is next exposed on Paddle Point, with a strike of S. 25° E., and again it can be approximately located in the bay just to the east of Turtle Point. The next three miles of its course can be fairly traced by the sections presented in the inlets of Snake Bay, although the grassy nature of the shores at these points renders it difficult in some cases to observe the actual contact. The line as mapped, however, is very nearly exact, the rocks being exposed at no great distance on either side of it.

Junction between Return Point and Sebaskong Bay.

Beyond the bottom of Snake Bay the line of junction runs through a rough bush country, and has not been traced in the interval between this and where it crops out on Last Point. In 1884, Mr. J. W. Tyrrell examined and made a log-survey of the west side of Crow Lake, and found the rocks throughout to be schists, and chiefly hornblendic in character, and this fact, coupled with the strike of the rocks as far as it has been observed on White-fish Bay, makes it altogether probable that the line of contact of gneiss and schist, which Messrs. Barlow and Smith have traced from Return Point across Snake Bay, is the same as that which comes out on Last Point, the strike of the rocks having curved around in the direction indicated by the coast-line of the bay. The line of junction crosses the narrows of White-fish Bay at Last Point, the rocks having a strike of about due west and a southerly dip. Thence it runs westward, and appears next on the Lake of the Woods side of the Grande Presqu'île, at the bottom of Burrow Bay. Between this point and Sebaskong Bay, a few miles to the south, the hornblende-schists are much mixed with intrusive gneisses, and the band which composes them appears to bifurcate and thin out rapidly towards the extremity of Rabbit Point, the rocks retaining their north-east or east-north-east strike, and the dip being prevailingly to the north west at high angles.

South side of Grande Presq'île.

The southern border of this tapering band of hornblende-schists skirts the north shore of Sabaskong Bay, often appearing on the off-lying islands, which, however, are for the most part composed of gneiss of a coarse, granitoid character. Westward of Rabbit Point the hornblende-schists appear to thin out completely for an interval, and are not seen again, save in small fragmentary patches on the island, till Stairway Point is reached, on the shore north of Split Rock Island. Here we come upon the thin end of an immense wedge, or rather lens-shaped area of hornblende-schists, which occupies the southern portion of the Grande Presqu'île and the off-lying islands for a distance of about ten miles, or nearly to the mouth of Sabascosing Bay. At Stairway Point the schists are inclined at low angles, 30° to 35°, and are seen to be interbedded with sheets of gneiss, which, however, occasionally breaks through the hornblende-schists transversely in dykes, thus indicating its intrusive origin, as does also the wedge-like characters of the more stratiform portions of the gneiss. The strike here is about N. 10° E., and the dip north-west. Westward, along the shores of the channel north of Split Rock Island, the strike gradually bends around to east and west, and in the vicinity of Sand Point to west-north-west. In the transverse section afforded by the channel between the main shore north of Sand Point and North Island, this band of hornblende-schists is seen to attain its maximum breadth of two miles. On

North Island the schist is frequently characterized by the presence of white feldspar, indicating a passage to dioritic schist. The band occupies the northern portion of North Island, and the whole of Fish, Fire-bag, and Rough Islands. A more westerly exposure is that of a small island about a mile and a-quarter south of Starting Point. On the southern portion of North Island a band of gray gneiss traverses the island from east to west, and skirts the shore of the channel to the east of Sand Point, dividing the main band of hornblende-schists from another smaller and apparently less regular band which occupies the south end of North Island and the greater portion of Rubber Island.

To the west and north-west of Starting Point this band finds its continuation in the hornblende-schists of Poplar Island, Dagger Island, and the islands between the latter and the mouth of Sabascosing Bay. These are in turn the south-west continuation of the pinched-in fold of hornblende-schists which extends southward along the line of the Tug Channel, from the main area of the Keewatin rocks in the vicinity of French Portage.

General outline of border round the Grande Presq'île.

It will thus be seen that the line of contact of hornblende-schist and granitoid gneiss has been traced from French Portage in an extensive ellipse, skirting the north shore of the Grande Presqu'îsle, the north-east and south sides of White-fish Bay, and the south and south-west shores of the Grande Presqu'îsle again, back to the starting point at French Portage. This encircling area, which is practically continuous, is constituted on the north by the main area of the Keewatin rocks, while on the south it is of the character of a narrow band, as if it were the remains of the folded outermost margin of the basin in which the Keewatin rocks were originally deposited. This encircling zone of schists embraces within it a great central area of coarse, granitoid gneisses, well displayed on the shores and islands of White-fish Bay, on the shores of the Grande Presqu'îsle, and on the inlets and lakes which extend into its interior. The whole structure is that of an immense anticlinal dome of upheaved gneiss, upon the flanks of which are arranged, concentrically to its outlines, the hornblende-schists of the higher series.

Spur of hornblende-schists.

The infolded band of hornblende-schists which branches off transversely from the main area to the south of French Portage and extends up the Tug Channel, crosses the channel obliquely in its southward course from the east side to the west, near the south end of Falcon Island. At the latter place the band divides into two spurs, one of which bends sharply around to the south-east, and finds its continuation in the same schists exposed in the neighborhood of Dagger Island, while the other spur extends westward across the south end of Falcon Island. The western extension of this band of hornblende-schists has

a breadth of over a mile and a-half, but ends very abruptly to the west on account of the sharp upheaval of the lower rocks in that direction and consequent on the irruption of large masses of granite. The southern margin of the hornblende-schists, *i. e.*, the line of its contact with the granitoid gneisses, crosses the north end of Oak Island and the middle of Brick Island. On the north-east end of Oak Island denudation has revealed the actual crest of the anticlinal folds of the strata, which thus appear like so many huge sheets of rounded boiler plate. The crest or axis of these folds dips to the east at an angle of 15°, a fact which may be taken as a strong proof that the upheaval which attended the irruption of the granites to the westward took place at a period later than that at which the schists were folded along the east-and-west axis. This well displayed inclination of the crests of folds is a remarkably good illustration of a system of cross folding which is more or less obscurely discernible throughout the region and which has been remarked upon by Dr. G. M. Dawson.* The infold of the Tug Channel is of course another notable instance of the effects of this cross folding, although this appears to have been contemporaneous with the ordinary longitudinal folding rather than due to a later local upheaval.

System of cross folding.

The area of hornblende-schists which thus occupies the south end of Falcon Island and the northern portions of Oak and Birch Islands, has infolded with it a considerable volume of a higher group of mica-schists and evenly laminated fine-grained grey gneiss, merging into micaceous or gneissic agglomerates in places. On either side of Sturgeon Channel these mica-schists are well exposed, but are not seen to the west of the granite which occupies Cyclone Island. To the south-east they are represented by the band of mica-schists which crosses Poplar Island about its middle. On either side of Deep Water Bay, a group of more or less gneissic schists, merging on the west side into agglomerates, and confined to the north and south by hornblende-schists, is observed. These are seen to cross Gardner's Island in bands alternating with bands of hornblende-schist. East-south-east of Birch Island the hornblende-schist is traceable across a string of islands to Bay Island where the schists curve around from an east-and-west strike to a south-east and then a south-west strike, the shape of the island conforming very closely to the curved strike of the rocks. This bending of the strike of the schists here seems to be due to an irruption of granite, the greater portion of which is probably concealed by the waters of the lake, but a portion of which is exposed on the south end of Poplar Island.

Rocks of Falcon, Oak and Birch Islands, etc.

*Geology and Resources of the Forty-ninth Parallel, p. 48.

On Windigo Island a band of black hornblende-schists runs through the island for nearly its whole length with a strike of 45°. It appears to have the character of an infold within the gneiss, and tapers off to a point towards the south end of the island. Other smaller bands and patches of hornblende-schist of a similar included or infolded character are not infrequent in the gneiss of this neighborhood.

Line of junction traced eastward from Rat Portage.

If we now return to our starting point, Hebe's Falls, the remaining portion of the outline of the area, so far as it has been actually traced, will be indicated going from that point eastward. It was found there that the schists and gneiss had a common strike of N. 80° E., and that the former dipped under the latter to the north. About two miles to the east-north-east the contact is again seen on the little lake that lies to the north-east of the town of Rat Portage, the rocks having the same strike and dip. Beyond this the line curves more to the north and is next observed where it crosses the narrows of Black Sturgeon Lake with a strike of N. 35° E. In the interval between this and the last exposure not only has the strike bent considerably from what has hitherto been its general trend, but the rocks have undergone such a tortion that the dip is here to the south-east, the schists occupying their normal relation of superposition to the gneiss. The breadth across the strike of these hornblende-schists at the narrows of Black Sturgeon Lake is only one and a-quarter miles. The strike at the eastern side of the belt is N. 26° E. and the dip west at high angles. This convergence of both dip and strike points to the structure of a synclinal trough, pinched in within the gneiss and tapering to the north. The extension of this belt of schists to the north of Black Sturgeon Lake is not a matter of observation, since the country in that direction is partially inaccessible. To the south the belt widens out very considerably and has a breadth along the line of the Canadian Pacific railway of four miles, or, in a direction at right angles to the strike, of two and three-quarter miles.

Tongues of Keewatin rocks

A mile farther east along the railway, from the base of this larger tongue of hornblendic schists, which runs north beyond Black Sturgeon Lake, is the tip of a smaller one, parallel in direction to the first, extending from the main area. The eastern side of this tongue of Keewatin rocks runs southward to the east of Hilly Lake, and the line of junction of schist and gneiss sweeping around its south end at a distance of a quarter of a mile from it, trends again to the south-east to a point on the Pine Portage and Rossland waggon road, one and a-half miles north of the office of the Pine Portage mine. Here it bends again sharply to the south, and can be traced approximately as mapped through the bush to where it passes the shaft of the Pine Portage mine about 150 feet to the east of it. South of this it can be followed

to the small lake, nearly due south of the shaft, which lies between the two series of rocks, and thence it runs south-east to cross the Long Lake Creek about fifteen chains south of the outlet of the lake.

Storm Bay to Route Bay.

It is next seen crossing the bottom of Storm Bay and then that of Route Bay. Inland the line is seen next on Hollow Lake, the north end of which is about two miles east of the Winnipeg Consolidated mine. The portion of the line of contact that has just been indicated as running in a sinuous course from the railway near Hilly Lake to the east of Big-stone Bay, is essentially a line of breccia, in which the gneiss forms the paste for broken fragments of schist. Numerous irregularly ramifying dykes of gneiss also penetrate the schist. This brecciated condition of the rocks is more characteristically developed to the south-eastward. It is observable where both the Pine Portage and the wagon road to Rossland cross the line of junction. The rock to the east of the line of junction, in the neighborhood of the Pine Portage mine, is perfectly granitoid in structure and presents the character of mass of intrusive granite. Traced easterly, however, along the line of its contact with the hornblende-schist it gradually assumes a more and more distinct gneissic structure, while at the same time its characters as an igneous intrusion along the contact become more distinctly marked. At the bottom of Storm Bay the rock is quite gneissic and yet it sends off dykes, whose foliation is not less distinct than that of the main mass, into the schist, and is in places thickly studded with angular blocks of the latter. The same thing is repeated and is well displayed at the bottom of Route Bay, where in places the gneissic foliation of the matrix of the breccia is distinctly seen to curve or flow around the angles of the included blocks. This breccia extends for considerable distances to the north-west of the line which defines the extent of the hornblende-schist as an unbroken mass.

Blind-fold Lake to Black River.

A section across the bare, burnt country, from the south arm of Blind-fold Lake to Hollow Lake, through which the line of junction runs, shows the breccia extending for half-a-mile from that line. Two miles and a-half to the south-east the line of junction it is again observed on a small lake east of the base of Pipe-stone Point. Beyond this, owing to the inaccessible character of the country, the line has not been actually investigated for a considerable distance. From the sections which it has been possible to make north and south from the end of Witch Bay, however, and from the rocks exposed on the Adams River, and those on the Black River to where the contact of schist and gneiss is again seen, there can be little doubt that the general disposition of the rocks is approximately such as is represented on the map, particularly as the country to the east and north-east is known to be all gneiss.

Between Black River and Long Bay.

On the Black River, at a point about four and a-half miles from its mouth, the green schist and granitoid gneiss are seen in contact, with a strike of about S. 25° E. and vertical dip. Between this and the inlet of Long Bay, where the contact is again observed, there is evidently an S shaped curve in the strike of the schists. Where the contact is met with on the shores of the inlet of Long Bay, the strike is S. 70° E. and the dip to the north, so that the schists pass under the gneiss. From the mouth of this inlet eastward for a couple of miles an area of gneissic agglomerate occupies a position between the schist and the gneiss. The line of junction of schist and gneiss is seen again at the extremity of Long Bay with a strike of S. 40° E. and southerly dip of the rocks, just before it passes beyond the limits of the area defined by the accompanying sheet. The contact here is distinctly brecciated and the matrix may be observed to pass from a massive granite, or a miceo-granite with porphyritic quartz and feldspar, through schistose varieties to a well foliated gneiss.

Relations of Keewatin to underlying gneisses

Having now sketched somewhat in detail the outline of this Lake of the Woods area of Keewatin rocks and explained the conditions found to obtain along the contact with the granitoid gneiss, by which the Laurentian is here represented, I shall proceed to consider briefly to what extent we are able to define the stratigraphical relations of the series. The series has hitherto been, at least provisionally, correlated with Logan's typical Huronian. Believing, as previously stated, that such a correlation is not justifiable upon evidence at present available, the relations of this series to the adjacent granitoid gneisses will here be considered quite independently of what may be the relations of the typical Huronian to the Laurentian. Any conclusions that may be set forth therefore have no necessary connection with the disputed question of the relation of Huronian to Laurentian; and if the same conditions are not also true of the typical Huronian, the difference will only constitute another strong reason for the belief in the geological disparity of the Keewatin and Huronian.

Conditions at Rat Portage

Apart from the differences among geologists as to the relations of the Huronian and Laurentian, there are also differences of opinion, not very strongly expressed, as to the nature of the relation which exists between the specific series of rocks here spoken of as the Keewatin, and the Laurentian. Dr. Bell states that the two series have the same strike and dip at the contact near Rat Portage, and the contact is alluded to as conformable.* Dr. G. M. Dawson adduces the same facts as to the appearance of conformity at the same place of

* Geological Survey of Canada, Report of Progress, 1872-73, p. 104

contact, but conjectures that the gneiss and schist have been brought into juxtaposition by a fault.* Dr. Selwyn and other geologists who have examined this contact have inclined to the opinion that the two series are in conformable relation to each other.

These opinions as to the conformity or unconformity of the two series have not, however, been based upon the examination of any extensive portion of the line of contact. A summary of the evidence bearing on this question, afforded by an examination of a great number of exposures showing the contact around the whole periphery of the area, will be of service in aiding towards the general acceptation of a definite conclusion upon the matter. It may be well to premise that the evidence points more ways than one, and that it is only by a critical investigation of it that we can arrive at the real facts of the case.

Supposed conformable junction of the two series.

The belief that the two series are conformable finds its chief support in the parallelism of the foliation of the gneiss and the lamination or bedding of the schists. This involves, of course, the assumption that the foliation of the gneiss is either actually the remaining traces of original sedimentation, or that the planes of the former are coincident with the now obliterated planes of the latter; and if the assumption is to hold it will be very difficult indeed to deny the conformity of the two series. It is, however, highly improbable that the foliation of the gneiss has anything to do with an original sedimentation. Numerous instances have been cited in the preceding pages of the brecciated condition of the contact of the gneiss and schist. Gneissic foliation is seen to have been developed in a rock which was once in so liquid or viscid a condition as to permit the passage through it of angular blocks of schist to considerable distances from the source from which they were detached. A rock to have been in a state so yielding must necessarily have had all traces of an original sedimentation, if any such existed, obliterated. Furthermore, the existence of a well-marked foliated structure in dykes which have been injected within the schist, both parallel and transverse to its lamination, and which are sometimes traceable in unbroken continuity with the main area of the gneiss, proves conclusively that such foliation was induced in the rock subsequent to its having been soft enough to have undergone injection, and therefore, to have had any traces of sedimentation destroyed.

Foliation does not indicate bedding.

In other words, the foliation of the granitoid gneisses is developed in rocks once viscid or plastic, quite independently of any arrangement due to sedimentation they may or may not have possessed. This conclusion does not necessarily imply that the gneiss and schist may not

*Geology and Resources of the Forty-ninth Parallel, p. 46.

have been originally sedimentary and conformable. As a matter of opinion, I incline to the belief that the granitoid gneisses of the Laurentian were never aqueous sediments, but the conclusion which the facts adduced lead to is independent of either the origin of the rocks or their original stratigraphical relations. It simply proves that the foliation is no indication of sedimentation, and that so far as the question of conformity depends upon it there is nothing to go by. The schists may have followed the granitoid gneiss in close sequence, and been laid upon it quite conformably, if its sedimentary origin be granted, but there is nothing in the foliation of the gneiss to lend support to such a supposition. Thus the main ground upon which the contention for the conformity of the two series is based is shown to be exceedingly weak.

Circumstances tending to show an unconformity.

On the other hand, it is difficult to find direct stratigraphical evidence of a marked unconformity, for the same reason that there are no reliable evidences of sedimentary stratification in the gneisses. There are, however, some considerations which point to a very distinct historical and natural break between the two series. The most evident of these is the sharp contrast in their lithological characters. The granitoid gneisses are essentially acidic rocks, while in the Keewatin the basic minerals predominate. No classification could require a more sharply defined line between two natural kinds of things than that which nature has drawn been the light-colored, coarse-textured, massive, highly feldspathic, acidic gneisses on the one hand, and the dark-green or black, fine-textured, schistose, basic, hornblendic rocks usually in contact with it on the other. The sharpness of the contrast is in itself eminently suggestive of so radical a change in the conditions of formation as to be tantamount to an unconformable break.

Again the Keewatin area presents, as has been already stated, the characters of a folded trough in which had rapidly accumulated a great local thickness of mixed volcanic rocks and aqueous sediments. The conception of such a trough or basin, which is forced upon one in a consideration of the geological structure of the region implies an unconformity. The fact that we find in the Keewatin series the first undoubted evidences for this region of aqueous sedimentation and also of volcanic action, while in the underlying Laurentian gneiss of the region we find evidence of neither, more than suggests that the Keewatin series had a totally different kind of origin from that of the gneisses, and must, therefore, be in unconformable relation to them.

Absence of fragments of underlying series.

There can be little doubt that in the volcanic origin of the basal member of the Keewatin series we must seek the explanation of the fact that there is found in it no detritus of the underlying rocks. The deposition of the volcanic material, from which have been derived by

processes of urilization and analagous changes, the altered traps and hornblende-schists, seems to have preceded the first discernable influence of water as a stratifying agency.

THE GRANITES.

The granitic intrusions of the area of the Lake of the Woods may be grouped under ten main centres of occurrence or distribution, with a number of bosses of minor importance, which appear to be independent of these. The existence of these granitic masses is a factor of prime importance in the consideration of the stratigraphy, and it is therefore convenient to speak of them in an order which the structure of the region indicates as the natural one from this point of view. Beginning at the eastern portion of the chief curvilinear axis of folding or upheaval of the trough, that order is as follows:— Structural importance of granite masses.

(1.) The Yellow Girl Granite Mass, with its ramifications to the N. W. and S. W. Enumeration.

(2.) The Deadman Portage Granitic area, comprising the Carl Bay and Portage Bay masses, with probable ramifications at Crow Rock Channel to the N. E., and on the shore of Shoal Lake, to the S. W.

(3.) The Canoe Lake Granite Mass, with its subordinate masses.

(4.) The Indian Bay Granite Mass.

(5.) The Big Narrows Island Granite Mass.

(6.) The Granite area, North-west Angle, comprising numerous sporadic masses of granite of small extent.

(7.) The Sioux Narrows Granite area.

(8.) The Poplar Bay Granite boss.

(9.) The Many Island boss (Gneissic in structure).

(10.) The Split Rock Island Granite area.

The Yellow Girl Granite Mass.

The Yellow Girl granite, in the main mass, occupies an approximately circular area of about four miles diameter in the central portion of the Eastern Peninsula, with a club-shaped extension running out from its south-western edge to the shores of the lake at Yellow Girl Point. In my first reconnaisance of the shores of this peninsula, while the details of the topography were being worked out, I observed that the strike of the rocks was everywhere conformable to the three directions which determine its general contour, or more simply, that the strike seemed to follow the shore-line, and run around the peninsula. This arrangement of the rocks naturally suggested a centre of upheaval about which the strata, exposed on the shores of the peninsula, had Relation to enclosing rocks.

been caused to assume a concentric attitude. The granite exposed at Yellow Girl Point, which was all that was then known, seemed only to interrupt the continuity of the rocks, and did not in itself afford an explanation of the stratigraphical conditions presented. Its presence, however, taken together with the very suggestive arrangement of the rocks, led me to conjecture the existence of a much more extensive inland mass of intrusive granite, of which that at Yellow Girl was only a ramification. On proceeding, the following season, to test the truth of this hypothesis, I was pleased to find it verified in the most satisfactory manner. Bear Bay was discovered, which, from its extremely narrow mouth, had been overlooked the previous year, and by the access it afforded me into the peninsula from the south, revealed the distribution of the granite, as mapped on the accompanying sheet. When water did not afford a means of approach, excursions through the bush from the south, west and north sides of the peninsula, with the object of locating the limits of this hypothetical granite mass were in every case attended with success, and the fact established that the larger central portion of the peninsula was in reality occupied by a great upheaval of granite, which had exerted a profound influence upon the structure of the strata through which it protruded. Towards the west end of Yellow Girl Bay the granite was found to come within a quarter of a mile of the south shore of the peninsula and its continuous extension from its contact here with the schists, was traced northward up the bed of a small creek, and north-westward over the bare rocky *brule*, well towards its central portions. From the east side, a brook, falling into the lake a couple of miles north of Yellow Girl Point, was followed up to the edge of the granite, and sufficiently far beyond to establish its identity with the mass observed at the points accessible from the south side. On the north side of the peninsula a continuous section of the strata was traced through the bush for a mile and a-half from the east end of Witch Bay, to the contact of what is apparently their lowest exposed member with the same granite mass, which is well shown for a considerable distance south of the contact. On the east the confines of the granite are determined only by inference. The traverse of the Adams river, with its exposures of a large development of mica-schist, constitutes a known limit beyond which the granite does not extend. The section southward from the end of Witch Bay, shows that the strike of the rocks bends around as the granite is approached from east to east-south-east, and in the north-east arm of Yellow Girl Bay the rocks strike N 35° E, so that there is a decided convergence, pointing directly to an arrangement of the strata concave towards the granite mass. The curve traced by the strike being assumed concentric with the

Definition of granite area.

Its outline.

general outline of the upheaved mass of granite, the latter must be limited on the east at a distance considerably within its extreme possible extension, as determined by actual observation on the Adams River.

Connected lines of upheaval.

The forces of upheaval which operated with greatest intensity in the central portion of the peninsula, and resulted in the extrusion from below of the main mass of granite also acted in lines radiating from this centre of activity, as is evident from the disposition of the smaller granite patches and dykes with reference to it. The club-shaped extension from the main mass to the shore of the lake at Yellow Girl Point, is continued in the same south-west direction, in a series of granite intrusions, portions of which are accessible to observation upon the islands for a distance of seven miles. The south end of Sepulchre Island is occupied by the same granite as that on Yellow Girl Point, and excellent exposures of it may be seen cutting the schists of the north end of the island, in dykes branching out from the larger mass. A mile and a-quarter south-west of Yellow Girl Point is a small island, the south half of which is occupied by granite, and half a mile west of this the eastern extremity, with a short portion of the south shore of Chisholm Island, is faced with granite. Between this and Beacon Island are a number of small islets, some of which are cut by granite dykes. Beacon Island lies a little less than a mile to the south of Chisholm Island, and is about a mile and a quarter from east to west, and a quarter of a mile in breadth. The south half of the island is all granite, with a feeble gneissic foliation developed in it at places in the neighborhood of its contact with the schists to the north. The point of land on the main shore immediately to the south of the west end of Beacon Island, is occupied by the same granite. Granite dykes traverse the schists on the east side of Cliff Island, and two small islands to the east of it are composed of granite, which is gneissic in places. Finally the centre of Cliff Island is occupied by a boss of granite with off-shooting dykes, which lies in the axis of an anticline, to the curve of which it seems to stand in the relatation of one of the foci of an ellipse.

Intrusions to south-west.

Intrusions to north-west.

At right angles to this train of granitic irruptions branching out from the main Yellow Girl mass is another trending from it in a north-westerly direction. This line of irruption lies in the axis of the peninsula, and forms the back-bone, as it were, both of the tapering portion of the peninsula and of the ridge marked by the belt of close-set islands, which connects its extremity with the opposite side of the lake at Crow Rock Channel.

Connection with Deadman Portage area.

This line of irruption and the ridge, of which it constitutes the axis or back-bone, is concave to the south, and both are apparently continued to the south-west of Crow Rock Channel, in the centre of the

Western Peninsula, so that there is established a continuous curvilinear line of upheaval, extending between the large Yellow Girl granitic mass in the centre of the peninsula, and the equally large area of irruptive granite which constitutes the nucleus of the Western Peninsula, in the neighborhood of Deadman Portage.

The first accessible exposure of this train of irruptive masses is on the shores of Bottle Bay. A long, narrow and apparently lens-shaped intrusion of granite crosses the bay in a north-west direction, and is plainly observed to cut the massive green schists on either side. It is accompanied by a number of small dykes, and these and portions of the larger mass have often, by a more rapid local cooling, been rendered so fine-textured as to be micro-granites or felsites in aspect, although for the most part the granitic texture is well developed.

Granite irruption an anticlinal axis.

This lens-shaped irruption of granite constitutes a true anticlinal axis, there being, as is shown in another place, the same sequence of rocks on either side of the median line of upheaval dipping in opposite directions away from it. The projection of this axis of upheaval west of the French Narrows is a line covered for some distance by the waters of the lake, Allie Island being just to the south of it. Where the line first meets with land, however, on the east side of Oliver Island, the rocks are again found fissured and traversed by another lens-shaped granitic intrusion, which crosses Oliver Island, and is exposed on the shores of the channel between it and Shammis Island. The rock is highly feldspathic and fine-textured, and although it might be classed with the felsites is undoubtedly a granite in composition, and in places the granitic texture is not lacking. Half a mile to the south of this granite mass, on the east side of Shammis Island, is a large dyke of the same rock abutting upon the shore-line. A portion of the south shore of Shammis Island near its west end is faced with granite, and an island a quarter of a mile long, lying opposite the channel between Shammis and Crow Rock islands is composed of it.

Dykes at Crow Rock Island.

The east end of Crow Rock Island is traversed by at least two large dykes, which strike with the schists and come out upon the shore facing Shammis Island. A number of large, somewhat irregular dykes is seen also to the west of Crow Rock Island. The east side of Micrometer Island, a little to the north of Crow Rock Channel, is occupied by a coarse-textured gray granite intrusive through the schists. Both sides of Crow Rock Channel expose irruptive masses of reddish granite of normal texture, which are continued in a series of dykes running with the schists along the shore to the west-south-west of the channel, and which are probably farther continued and merge into granitic offshoots from the Deadman Portage area.

The Deadman Portage Granite Area.

Central mass of Western Peninsula.

The tracing out of the line of anticlinal irruptions, which radiates from the Yellow Girl mass in a north-west direction, and then curves around to a west-south-west direction towards Crow Rock Channel, leads us naturally to an area of granite which stands in a relation to the Western Peninsula and the strata which compose it, analogous to that which the Yellow Girl mass bears to the Eastern Peninsula and its rocks. The Deadman Portage granite area comprises two distinct masses. The first of these is chiefly exposed on the shores of Carl Bay, on the Shoal Lake side of the portage. It is oblong in shape, the longest direction of the mass running from north-east to south-west. In this direction it has been definitely ascertained to have a length of at least four miles and a-half, but its extension to the north-east of Carl Bay probably adds considerably to this observed distance, so that its total length may be taken at about seven miles. It has a breadth transverse to this direction varying from a mile to a mile and a-quarter.

Character of junction with schists.

The continuous line of exposure afforded by the shores of Carl Bay, and its relations to the rocks on the south, (revealed by sections examined over a comparatively bare country,) show that the mass is intrusive through schistose hornblende-rocks. On its northern border there has been developed in the granite a distinct foliation, the planes of which are arranged parallel to the line of contact with the schists, so as to form a border or selvage of gneiss, from an eighth to a quarter of a mile in breadth between the more granitic portion of the mass and the hornblende-rocks. The hornblende-rocks in contact with this gneiss on the north side of the intrusive mass are blackish-green in colour and fissile. On the south side of the mass the foliated structure was not detected in the granite in the vicinity of its contact with the hornblendic rocks, which were also, it is interesting to note, much more massive and less schistose than those on the north side. In crossing the neck of land which separates Carl Bay from Portage Bay and at the narrowest point of which is the canoe-path known as Deadman Portage, we traverse a belt of rather massive schistose hornblende-rocks, with some trappean rocks of undefined relations to the schists, the whole having a breadth in the line of the portage of about a mile. This belt of schistose hornblende-rocks and traps separates the Carl Bay granite mass from that of Portage Bay on the Lake of the Woods side. This mass of granite occupies the shores of the eastern part of Portage Bay and almost the whole of the peninsula that separates it from Outer Bay. Its greatest length is about four miles in a direction nearly parallel with the longer axis of the Carl Bay mass, and its greatest breadth is a mile and a-half. The irruption has taken place

along the line of contact of the schistose hornblende-rocks, which lie to the west of it, and a thick group of micaceous and greenstone agglomerates which lie against it on the east. The granite has apparently forced the two formations apart to make room for itself, since the strike of the schists is concentric with its periphery, and the long axis of the granite mass is in a line with the common strike of both hornblende-schist and agglomerate when seen in its normal north-east and south-west direction at their contact in the north-east arm of Portage Bay.

Boundary to the south-west.

The boundaries of this granite mass are well defined by exposures affording easy facilities for observation, except to the south-west, and in this direction its extension is limited by a bush traverse westward from the most northerly arm of Monument Bay, which proved that the granite does not extend that far. The irruptive energies which gave rise to the granite were not, however, altogether expended on the main mass at Portage Bay, for farther to the south, on the shores of Monument Bay, large dykes with a north and south trend are found cutting the schists. Two of these are observed in the north-east part of the bay and two others at its western end, all composed of the same granite as that of Portage Bay.

Dykes.

Granite assuming a gneissic aspect.

It is altogether probable that the area of coarse-textured grey rock, colored on the map as gneiss, occupying part of the south-east shore of Shoal Lake, and a number of the outlying islands, is associated in origin with the granite mass of Carl Bay. It lies in the same general axis of irruption, and although its relations to the adjoining rocks are not sufficiently observable to decide definitely whether it is an irruption or not, its roughly foliated texture which claims for it the name gneiss, by no means precludes the possibility of its being a true irruption. In some places, as on Elm Island, this rock is granitic in texture as well as in composition, no foliation having been developed in it. The grey color of this rock is in harmony with what seems to be a rule of general application in this region, that where a granite, of true granitic texture, merges into a foliated variety of the same rock, there is a differentiation in color as well as in structure, the granite being for the most part red and the gneiss grey.

Associated felsites.

Associated with the granites of the Deadman Portage area is another class of acidic irruptions of secondary character. These are lithologically classed with the felsites, which here as elsewhere occur as intrusions in the vicinity of large granite masses. In the intrusive area under consideration these are of two kinds, (1) a fine, even textured, whitish, to honey-colored felsite, with sparsely distributed grains of clear quartz; (2) a grey porphyritic rock, described as a felsite or micro-granite (Section No. 44, p. 35 CC). A small patch of the first of

these breaks through the green schists of the south side of Carl Bay close to the portage. Another boss of the same felsite occurs in the hornblende-schists about a mile west of the bottom of Monument Bay.

Large felsite mass.

The second variety of felsite is however much more largely developed. A large mass of it breaks through the belt of hornblende-schists that intervenes between the granite masses of Carl and Portage Bays and is well exposed on the shores of Portage Bay and Partridge Lake. Its extension south of the latter lake is conjectural; but the occurrence of so large an irruption of the character of a felsite porphyry or micro-granite, in such a relation to the two extensive masses of typical granite is very interesting. Whether it is the result of an earlier or later manifestation of the same irruptive energies that gave rise to the granite or is contemporaneous with it, there is no direct evidence to show. It is altogether probable, however, that all three have had a common origin, and that the micro-granite differs from the true granite, not in age, but in conditions of pressure and rate of cooling which have decided the differentiation of the crystalline structure of the resulting rocks. A smaller mass of the same micro-granite is observed interrupting the agglomerate-schists of the north shore of Monument Bay, through which it is probably also irruptive as is indicated on the map.

The Canoe Lake Granite Mass.

Third nuclear granite mass.

Thus far we have seen that within the Keewatin area the two prominent masses of land, the Eastern and Western peninsulas, whose resistance to denudation has been such as to prevent their degradation to the submerged level, to which disintegrating forces have reduced so large a portion of the area, have had as their nucleæ or central portions extensive irruptions of granite. To the north-west of the Western Peninsula lies another irregular peninsular mass of land, separating the waters of Shoal Lake from those of Ptarmigan Bay. This also has for its nucleus an immense boss of irruptive granite. This intrusion it is convenient to refer to as the Canoe Lake granite mass from the lake of that name, on the canoe route from Ptarmigan Bay to Shoal Lake, on the shores of which it is continuously exposed. It is a coarse textured, red, biotite granite with probably some muscovite. It breaks through a group of coarse and fine-textured trap-rocks, and fine-textured compact slightly schistose hornblende-rocks, the schistose structure varying much in intensity both in the traps and the hornblende-schists. The intrusion marks the development of a well-defined anticlinial dome, the dip of the rocks wherever observable all around the peninsula being away from the central mass of granite.

Exposures defining it good. The exposures upon which the mapping of this granite irruption is based are sufficient to place its extent and relations to the confining rocks beyond conjecture. On the south side of the west end of Echo Bay the shore, for the distance of a mile, is composed of it, much mixed towards the western end of this distance with portions of the rather massive, fine-textured, hornblendic schists through which it breaks. Granite becoming a felsite These schists, in the vicinity of the contact, are here also irregularly mixed with intrusions of a felsitic rock, which is probably simply a modified form of the granite. At the eastern end of the same distance the granite as it approaches the contact of the schists displays a very marked tendency to become fine-textured and assume the aspect of a red felsite rather than of a granite. This felsite-like modification, which very probably owes its physical condition, as contrasted with the true granite, to the greater rapidity with which it cooled near the contact, also exhibits a marked tendency to split in different directions under the hammer, as if a crude kind of schistose structure had been developed in it. A very distinct transition may be traced from this felsite or micro-granite variety of the intrusion to the coarsely granular varieties, within a distance of a hundred feet, and the feeble schistose tendency was observed to persist even beyond the point at which the granular structure became distinct. A portage of about ten chains, to the south leads up to Canoe Lake, on the whole of the shores of which the granite is well exposed, to the portage at its western extremity whereby we descend to the level of Shoal Lake, by a rough path about a quarter of a mile in length. Near the western end of this portage Brecciated contact with Keewatin rocks the line of contact of the granite with the hornblendic rocks is crossed. The contact here is distinctly brecciated, the granite penetrating the schist in large dykes and holding broken fragments of it. At the mouth of Bag Bay the contact is again well seen and the intervening breadth of schists between this and the contact on the portage just referred to is cut by transverse dykes of granite branching out from the main mass. In Bag Bay the granite is continuously exposed, and sends off dykes into the schists at its contact with them on the south side of the bay. On the south side of the peninsula the granite is next exposed at the bottom of Hell-diver Bay.

Isolated mass. Following around the south-western shores of the peninsula an exposure of granite occurs on the Shoal Lake Narrows near where it widens into Labyrinth Bay. This was at first supposed to form part of the same granite mass as that which I have been describing, but an excursion through the bush over a bare stretch of country, from a point on the shore to the north of it, proved its isolated character. A variety of hornblende-schists, coarse diorites and serpentines occupy the area between it and the larger mass, while in the vicinity of its exposure

on the shore of the narrows the rock is chiefly an altered diabase-schist. The next exposure of the granite mass met with is one of over a mile in extent on the western shores of Squaw Lake, whereby access is afforded well into the heart of the peninsula from the Ptarmigan Bay side.

The longest axis of this mass of granite measures six miles, and lies parallel to that of the Carl Bay mass in an east-north-east and west-south-west direction. The breadth of the mass is three miles. **Concentric felsitic intrusions.**

A very interesting feature connected with this extensive intrusion is a series of concentrically arranged felsite intrusions which break through the schists at a certain comparatively uniform distance from its border. These may be noted briefly in order, the map being chiefly relied upon to give an idea of their relationship to the granitic mass. The first has already been referred to as the purple felsite described by Mr. Bayley in section No. 28 (p. 34 C C.) It occupies the extremity of a point of land on the south side of Echo Bay, apparently intrusive through the hydromicaceous schists that form the shore. Whitish felsites occur, as has been noted, breaking through the schists near their contact with the granite at the extreme west end of Echo Bay. On the north side of Clytie Bay are two large patches of similar whitish to honey-colored compact felsite, whose irregular relation to the green schists of the shore is quite suggestive of an intrusive origin. The first of these occurs at a distance of half a mile from the contact of the schists they cut with the granite, and the second and larger is half a mile farther west. On the outer side of the arm of land which separates Bag Bay from Shoal Lake, and on the off-lying islands, are a number of these felsite intrusions. Of these a whitish felsite described as Sections No. 42 (p. 34 C C) is a fairly typical example, and is taken from an island composed of it which lies a mile and a-quarter south of the entrance to Clytie Bay. A mile south of this island the narrow projecting strip of land which forms the turning point of the shore is entirely composed of the same felsite. A mile and a-half south-south-east another mass of it is seen, on the west side of a small bay, while the east side of the peninsula which separates this bay from Hell-diver Bay is almost entirely composed of the same rock, which is seen on the south side of the west end of the latter bay to cut the schists in distinct dykes. One or two other instances of similar occurrences of felsite of small extent were observed on the same shore farther east.

Regarding all these felsitic intrusions in their relation to the granite mass, we find that they lie in a belt concentric with its border, from which they are nowhere more than a mile and a-half distant, and that they appear to have had the most favorable conditions for their occurrence on the north, west and south sides of the granite, although **Their character**

the fact of their not appearing on the east side is very possibly due to difficulties of observation, there being a considerable breadth of country between the shore-line and the granite in which such intrusions may exist without being apparent on the chief line of exposure along the shore. These felsites seem to bear an analogous relation to the Canoe Lake granite as to that borne by the mica-granite and felsites of the Deadman Portage area to the granites there, and, like them, are probably associated genetically with the granite.

Subordinate granite bosses continuing main mass.

The irruptive forces which gave rise to the Canoe Lake granite mass, show evidence of having extended their activity far beyond the main intrusion and beyond its encircling zone of felsite dykes. If the longer axis of the Canoe Lake mass be projected east-and-west, it will be found to pass in the immediate vicinity of subordinate granite bosses on either side. On the west side this projected axis of irruption is seen to be coincident with the axis of a great anticline, which brings the lower granitoid gneisses to the surface in Snow-shoe and Rice Bays, and on the shore of Shoal Lake for three miles to the south of these. This upheaved area of granitoid gneiss is cut, where it forms the west shore of Shoal Lake, by intrusions of granite which are grouped about a line that forms the common axis of the upheaval and of the Canoe Lake irruption. These granites are very red in color and coarse-textured, and present a sharp contrast to the lighter colored gneiss through which they break. They are exposed in two distinct patches on the shore, with a small breadth of gneiss intervening, and on the outlying islands, as represented on the map.

Three subordinate intrusions

The eastward extension of the same axis of upheaval or irruption has, grouped about it, three subordinate intrusions. The central of these is almost exactly in the line, and takes the shape of an irregular, large, dyke-like patch of granite, cutting the agglomerate-schists on the south side of the west end of Ash Bay. Its granitic structure is well developed in some places, but for the most part, its texture is that of micro-granite. It is flesh-red in color, and displays a crude sort of cleavage under the hammer. It resembles very closely the selvage of red felsite, described as characterizing the northern limits of the Canoe Lake granite mass at its contact with the schists on the shores of Echo Bay. To the south-east of this, on the north side of Labyrinth Bay is a small boss of granite, which seems to occupy the heart of an anticlinal arrangement of the schists through which it breaks, as will be seen from the structural section C–D. At the narrows, between Copper and Cork-screw Islands, an irregular intrusion of granite cuts the schists on either side. In places it breaks up into distinct dykes, and is associated with a whitish felsite rock on its north side, which doubtless bears the same relation to it, as do the encircling felsites to the Canoe Lake mass.

The Indian Bay Granite Mass.

This is an intrusion of considerable extent, though much less in size than the Canoe Lake mass, and is a coarse-grained, red granite. Its extent as mapped, is inferred from a continuous exposure on the north shore of Shoal Lake, and another at the eastern end of Indian Bay, taken together with the strike of the rocks that surround it. As will be seen, its long axis has, approximately, the same direction as that of the Canoe Lake mass and of the Carl Bay mass.

Outline of mass

The south-eastern confines of the mass are in contact with a breadth of mica-schist, in a vertical attitude. At its western extremity, where exposed at the east end of Indian Bay, it is also in contact with mica-schist. At the western end of the Shoal Lake exposure there is a marsh-covered interval between the granite and the next rock to the south, which is a massive hornblende-schist, merging into a greenstone-schist. This covered interval probably represents that occupied by the mica-schists, as it is in the same relative position with regard to the granite as are those mica-schists above mentioned, and lies between them. Thus it is probable that the granite is in contact along the whole of its southern border with mica-schist. On its northern border, on the Indian Bay side, the mica-schist is not seen, and a schistose hornblende-rock is the nearest observed to the granite. We have no warrant for assuming that the mica-schist completely encircles the mass, although it is continuous around half of its border.

Granite on Snow-shoe Bay.

A small patch of granite, cutting the gneiss, of Snow-shoe Bay, near its contact to the north with the agglomerate-schists at the mouth of the bay and the granite of an island about half-way between the entrance of Indian Bay and that to Clytie Bay, may be regarded as probably associated with the Indian Bay mass.

The Big Narrows Island Granite Mass.

General relations of this mass.

The general relations of this granite mass to the structure of the strata, may be best described by saying, that it lies in a secondary curvilinear axis of upheaval, to the south of, and concentric with, the main arch of granitic irruption, of which the nuclear bosses of the Eastern and Western peninsulas are, so to speak, the supporting buttresses. The mass occupies the central portion of Big Narrows Island. Its presence at this point seems to have conditioned the size and shape of the island. The latter is one of the largest in the lake and its general outline is that of a lens, tapering to slender points to the north-east and south-west, and having the granite as a nuclear mass in the line of its greatest thickness. The granite occupies an area, in

the west of the island, a mile and three-quarters in length, and a little less than a mile in breadth. The granite varies in texture and in color. For the most part it is an ordinary coarse-grained, red granite. Near its contact with the schists, at the mouth of Turtle Bay, however, it assumes, in places, a very coarse, pegmatitic structure, with but little mica present. On its northern border, as exposed on the south side of Quandary Bay, there is developed in it a fairly, well-marked gneissic foliation of the constituent minerals. When this gneissic structure exists the feldspar is less red, and the whole rock is, in consequence, of a much lighter colour, tending to appear in grey rather than in red tints, as found in other cases under the same circumstances.

Relations. The exposures are sufficient to determine, with moderate accuracy, the extent of the mass and its relations to the confining rocks. The intrusion breaks through mica-schists, or micaceous quartzites, the strikes of which, where not immediately interrupted by the granite, tend to curve around it and converge at either end. On both sides of the granite mass the schists are, at their nearest exposures to the contact, in a vertical attitude, but a little farther away they are seen to dip at high angles towards the granite.

Quandary Bay. Some patches of dark-green hornblende-schists, small in area, are observable on the shores of Quandary Bay, apparently intervening between the granite and the mica-schist, and on the south side of Turtle Bay there is a considerable exposure of a rather massive green schist, quite chloritic, which is surrounded by the mica-schists, but does not reveal its structural relations to them. On the south side of the mouth of Quandary Bay, a patch of schist-agglomerate, in contact to the south with a fragment of a belt of mica-schist, is partially surrounded by the granite, and has apparently formed at this place the confining rock of the aperture of irruption. In the same line of irruption there is found on the north side of Rope Island a mass of gray granite, about a quarter of a mile in extent.

The general attitude of the rocks of Big Narrows Island is that of a synclinal fold, and it would appear as though the granite had been intruded from below at a date posterior to the formation of the syncline, so that although it is quite correct to speak of the line of injection as an axis of upheaval, the upheaved rocks had probably already in a large measure been folded.

Relations of other granite masses. The two other important granite areas, viz: the North-west Angle area and the Sioux Narrows area bear somewhat analogous relations to the general distribution of the Keewatin rocks. The one lies to the south-west of the Keewatin area, and the other to the south-east of it, and both are in the immediate vicinity of its contact with the granitoid Laurentian gneisses. The one is at the western extremity of the exten-

sive schist-surrounded dome of granitoid gneiss, presented in the Grande Presqu'îsle, and the other lies approximately at its eastern extremity.

The North-west Angle Granite Area.

This area lies opposite the mouth of the North-west Angle Inlet and is described to some extent under the above name by Dr. G. M. Dawson, who, however, in his reconnaisance of the lake did not attempt to map the distribution of the granite definitely. As mapped on the sheet accompanying the present report it appears as a cluster of sporadic patches of granite, stretching from Flag Island to the north end of Falcon Island, and lying between the latter island on the east and Windigo Island on the west. The sporadic character of the granite is more apparent than real, however, and is due to the irregular distribution of land and water, the latter often concealing the connection between different masses of granite. These occur in such a way that none can be proved to be completely isolated from any other, so that possibly there may in reality be but one irruptive mass. It appears probable, however, that there are three distinct masses at least. The first of these occupies the northern portion of Fly Island, the south end of Wind-fall Island, Passage Island, Cyclone Island and the small islands to the south of it. The second comprises the granite of the west and north sides of Wind-fall Island, the north-east tip of Windigo Island, the granite of the small islands between the latter and Falcon Island, and the two more southerly patches that appear on the west shore of Falcon Island. The third mass consists of the granite patch near the north end of Falcon Island and on some off-lying islands. The grani'e is mostly red coloured, and coarse-grained, sometimes with porphyritic crystals of feldspar. The mica is prevailingly black. The rock is nearly everywhere intrusive through the granitod gneisses of the Laurentian, the exceptions being the part on the north-east end of Windigo Island, which appears at the contact of the gneiss with an infolded belt of black hornblende-schist, (the intrusive rock cutting and forming a breccia with both gneiss and schist) and the granite of the west side of Wind-fall Island, which is in contact to the west with some agglomerate-schists and dioritic breccia. The intrusive character of the granite cannot always be demonstrated, inasmuch as where it occupies entire islands no contact features are observable, and in a few places, particularly on the west shore of Falcon Island, there does not appear to be a distinct line of separation between the granite and the gneiss. In other cases, however, where the contact is observable, the granite is seen to cut the gneiss and is unmistakably intrusive, so that the intrusive character of the whole may be fairly inferred.

Sporadic appearance on map.

Character and distribution.

Dykes and veins.

The red granite of the south end of Wind-fall Island contains sharply angular blocks of black hornblende-schist, some of which are traversed by small irregular veins of white quartz, which terminate abruptly upon the contact face of the granite, thus showing that the veins existed in the hornblende-schist prior to its inclusion within the irrupted granite. The activity, which found its strongest expression in the granite irruptions that cluster around Wind-fall Island, makes itself manifest for considerable distances beyond this. Smaller dykes of granite cut the gneiss beyond the limits assigned to the area. A number of these are observed cutting the gneiss on American Point, and on the shores of the inlet to the west of it, and the south-west end of Poplar Island is occupied by a boss of granite which forms a well-defined breccia with the mica-schists through which it breaks. This lies in the same axis of folding as the granite of Cyclone Island, and seems to indicate a chain of connection between the North-west Angle granite area and that of Big Island and Painted Rock, the other links of which are concealed by the waters of the lake.

Granite boss.

The Sioux Narrows Granite Area.

Distribution and character.

The main mass of granite in this area of irruption is well exposed on both sides of the Sioux Narrows, towards its eastern end, and on the islands that lie between. Geologically it occupies the central portion of the narrow belt of hornblende-schists and associated traps that stretches out from the south-east corner of the area of Keewatin rocks, and connects them with the larger developments of the same series in the country to the east of the Lake of the Woods. The long axis of the mass is coincident with the strike of the belt and of the strata which compose it. Its greatest length in this direction, so far as it has been observed, is about four miles, but it probably extends much farther eastward than it is mapped, under the waters of the lake. Its breadth is about two miles. The granite varies in color from reddish to pinkish-grey. In texture it is mostly coarse-grained, but in places, especially at the east end of the Narrows, on the south side, it merges into a very fine-textured, compact, reddish felsite-like rock, similar to that described as constituting the northern border or selvage of the Canoe Lake granite mass as exposed on Echo Bay.

Contact breccia

To the west of this main mass of granite, and occupying the south shore of the Narrows for the distance of a mile to the east of the narrowest part, is a brecciated mixture of the granite and schist. The green schists have been shattered and fractured in every direction, and the fissures have been injected with granite, so that the original country rock is now seen to be penetrated by innumerable,

anastomosing dykes which form so large a proportion of the present rock as to give it all the characters of a breccia on a large scale.

Just west of this breccia on the same side of the narrows is another mass of granite, exposed on the shore for about three-quarters of a mile, and on two of the off-lying islands.

Smaller granite masses.

Half way between the Sioux Narrows and Rendezvous Point is another somewhat extensive boss of red granite lying in the line of junction of the hornblende-schists and granitoid gneiss, both of which it cuts. It is about two miles in length in a direction transverse to the line of junction which it interrupts, and is at least over half a mile in breadth, possibly a mile, as its limits have not been traced out on its north side. This boss and a smaller one breaking through micaceous schists at the east end of Yellow Girl Bay are in a line with the Yellow Girl granite mass and that of Sioux Narrows, and would thus appear to form a chain of connection between them. Still another boss of granite, that may for convenience be grouped with the Sioux Narrows mass, was observed, on a bush traverse, cutting the gneiss about a mile and a-half north of the north shore of Long Bay. It is a coarse-textured red granite. The extent of its distribution is not known.

Poplar Bay Granite and Quarry Island Gneiss.

Within the area of the Keewatin rocks there are two other isolated irruptive bosses to be noticed. The first of these is the Poplar Bay granite, a reddish to flesh-tinted, coarse-grained rock breaking through green schists on the north side of the bay and on the larger island in its central portion. This has a length of about a mile in a north-north-east direction and a breath of half a mile. The strikes of the rocks of the bay display a tendency to arrange themselves parallel to the edge of the granite, although those in its immediate vicinity appear massive and do not afford satisfactory observations for the strike. The dip is irregular in direction sometimes away from and sometimes towards the granite, but always at very high angles.

Other granite bosses in Keewatin rocks

The Quarry Island boss lies in the axis of what appears to be a fold in the strata, the terminal portion of which runs out into the area of the granitoid gneisses in the tongue of schists at Pine Portage. Its exact extent has not been definitely determined, especially on its north side. It is, however, well exposed on the channel between Quarry Island and the main shore, and its distribution on the former has been pretty well made out. In these exposures it is seen to be a very coarse-textured gray granitic rock presenting a roughly but distinctly foliated structure. Its length is probably about a mile, and

lies in the direction of the median line of the stratigraphical fold indicated by the distribution of the rocks in the neighborhood of Pine Portage. Its breadth is half a mile. The boss is intrusive through more or less massive green schists, and on its west side the gneiss seems to have become intimately mixed with its contact rock, giving rise to a schist of transitional character between the gneiss and the country rock. This schist, though a coarsely-textured rock, presents a ready cleavage which has the aspect of a slickensided surface, as if the schist had been developed by a process of rubbing or slipping along the contact of the gneiss with the green schist.

Split Rock Granite.

Granite mass in gneiss.

This granite mass breaks through grey, coarse-textured, granitoid gneiss on the peninsula which forms the north-east extremity of Split Rock Island. The same granite occupies the island lying off the extremity of the peninsula, as well as the island immediately to the south of this. It also forms the shore for several miles of the north-east end of Big Island. The rock is, for the most part, of a red color, and is a typical granite. It is interesting, as compared with the other granitic areas that have been described, in being confined wholly within the Laurentian gneiss.

General Conclusions respecting Granite Masses.

Having considered briefly the leading features of the various granitic irruptions that occur within the field, it may be well to state, in short form, the general conclusions which seem to be fairly deductible from the observations made.—

Age, relations and character of the granite masses.

(1) The granite cuts both the granitoid gneiss (Laurentian) and various rocks of the Keewatin series, and is therefore of later age than either.

(2) The granite masses have a definite relation to the stratigraphical structure.

(3) They appear to lie in the lines of folding, with much of which they have been concomitant, primarily as an effect due to the same cause as that of the folding, and secondarily, as a cause of folding and pressure.

(4) A granite, the intrusive characters of which are undoubted, may merge in the same rock-mass into a granitoid gneiss without the latter losing those distinctive characters or proofs of its intrusive origin.

(5) The granite is, as a rule, a red-colored, biotitic, muscovite granite, of coarsely granular texture, but wherever a gneissic foliation has been developed in it, the rock tends to lose its red color and become grey.

(6) In the same rock-mass, towards its borders, the granite may have cooled into a compact-textured, homogenous, felsite-like rock, in which is not infrequently developed a crude sort of cleavage.

(7) There is a marked association of felsites, or micro-granites, with the main granite masses, there being an apparent tendency on the part of the former to an arrangement concentric with the periphery of the granite.

The Stratigraphical Relations and Structure of the Rocks Constituting the Keewatin Series.

Resumé of points already treated.

A consideration of the general aspect and geological conditions of the series of rocks with which we are dealing seems to warrant the assumption, already alluded to, that they have been laid down in and folded within a trough in the Laurentian formation. This assumption is strengthened by an investigation of the stratigraphical structure of the belt within which they are comprised. By way of preliminary to a statement of the results of such an investigation, we have thus far reviewed (1) the lithological character of the more typical rocks; (2) the conditions found to obtain along the line of contact of the basal members of the series with the granitoid gneiss on the borders of the trough; and (3) the leading features and distribution of granite irruptions, which have played so important a part in the development of the structure of the belt.

Different component parts.

A very cursory examination of the field is sufficient to establish the fact that there enters into the formation of the series a number of distinct and well characterized groups of rocks. The determination of the mutual relations of these groups, however, of their relative places in the the stratigraphical column, or in geological time, is a problem attended by many difficulties, and presenting no very satisfactory solution. Some of the difficulties that are encountered in this particular field may be mentioned here, since it is desirable that they should be carefully weighed in the estimation of the results arrived at.

Difficulties met with in correlation.

(1) The strata throughout the field are tilted at very high angles, and inversions are not infrequent, so that the order in which the rocks are met with, across the strike, gives no clue in itself as to which are the higher or lower members of the series.

(2) The rocks are quite devoid of such aids to correlation as fossils.

(3) The conception of the series as a mixture of altered volcanic ejectamenta and aqueous sediments, laid down sometimes syncheonously, and sometimes in alternations, implies the accumulation of overlapping and interchanging strata, differing in lithological char-

acter, some of which might be largely developed in one portion of the basin, and be very meagerly represented or altogether wanting in another at no great distance away. Such irregularities in the stratification, though perfectly in accordance with the ordinary processes of nature, seem to be strongly accentuated in these ancient formations; and in proportion as the rocks are folded these irregularities become more difficult of specific explanation, though readily enough accounted for in a general way. There is even a possible source of error in the tendency on the part of an observer familiar with the comparatively uniform conditions which obtain in the later fossiliferous rocks, to look for and pre-suppose a regularity in stratification which does not exist in nature.

(4) To satisfactorily correlate the rocks, it is therefore necessary to trace them closely from point to point; but this the nature of the ground and the large expanses of water often render impossible. Hence a certain amount of conjecture is introduced which is not present in the working out the relations of fossiliferous strata.

Description of Section C-D.

The most convenient method of approaching the question of the geological composition of the series and the mutual relations of its various members, is to consider a section across the belt, where the rocks seem to be typically developed, regarding the conditions there presented as typical for the area, and as a standard for comparison with analogous conditions found in other portions of the belt. For this purpose I have selected the section indicated on the map by the line C–D, as best suited to illustrate the character of the belt across its entire breadth. This section is over twenty miles in length in a direction transverse to the strike of the strata, and cuts the belt about its middle.

Groups of rocks met with.

The various groups of rocks met with in this section are:—

Granitoid gneiss at either extreme.

Hornblende-schists with associated altered traps, the whole more or less chloritic.

Agglomerate-schists, varying in character from greenstones to micaceous or gneissic schists.

Quartzose mica-schists, sometimes gneissic but lamination very even.

Hydromicaceous and chloritic schists, and micaceous slates.

Granite (irruptive).

Apparent relationship of these.

A first glance at the section disclores little or no relationship or periodic arrangement between these various groups. The two extremes of the section, where the series is observed to be in contact with the granitoid gneisses, afford us, however, starting points from which to trace out the sequence. The nature of this contact at either end of the section, both at Rice Lake and at Beaver Inlet, has already been

described in previous pages. On the assumption that these granitoid gneisses are inferior to the Keewatin series as a whole, we have in the hornblende-schists, which lie in contact with them, the basal member of that series. Proceeding inward from this contact along the line of section, we ought to be able to trace out on either side of the belt the sequence of the strata in ascending order. This we can do, but unfortunately for our attempt to find a regular law in the natural arrangement of the strata, the sequence at one end does not correspond with that at the other end of the section, and we are confronted at the outset with that lack of uniformity which is so characteristic of the whole series, and which dissipates so unceremoniously any notions that may have been entertained of these strata having been laid down and folded like so many layers of cloth.

North side of belt. On the north side of the belt there is seen in immediate contact with the black hornblende-schists, a breadth of a mile and a-half of northerly dipping agglomerate-schists, which in the vicinity of the section are more or less micaceous or gneissic in character, but which, traced eastward in continuous exposure along the shores of Clear-water Bay, merge directly into greenstone-agglomerates, composed largely of feldspathic and hornblendic or chloritic minerals and apparently clastic rocks of volcanic origin.

South side of belt. On the south side of the belt there is in contact with the hornblende-schists, and apparently partially infolded with them, a group of mica-schists, which not unfrequently pass by an admixture of feldspar into evenly laminated, fine-textured, gray gneiss. There are three possible explanations of this disparity. Either both rocks are of strictly contemporaneous origin, depositions of different character having been laid down at the same time in the two different portions of the trough; or the mica-schist is of prior origin, there being no deposition going on in the northern portion of the trough while it was being laid down in the southern; or the reverse is true, and the agglomerate antedates the mica-schist, but was not deposited uniformly on top of the hornblende-schist throughout the area. The facts cited below indicate that the last is probably the correct explanation.

Periodic arrangement discernable. Notwithstanding this lack of correspondence, however, between the sequence on the two edges of the belt, where we have a known base to start from, there is discernable in the section a certain periodic arrangement of the different groups of rocks. Going southward from the contact with the granitoid gneiss at Rice Lake the section shews a breadth of hornblende-schist, which, taking 75° as the average dip, is estimated to have a thickness of about 5,000 feet, a little to the east of the line of section, where not interrupted by the intrusive gneiss. Following this in ascending order we have a breadth of a

mile and a-half of agglomerate-schists, with some minor bands of intercalated hornblendic schists, and micaceous or hydromicaceous slates. These have a northerly dip at angles between 70° and 80°. Making allowance for the dip, these agglomerates have a thickness of about 7,650 feet. To the south of this, with a width of three miles, is a group of alternating bands of micaceous, hydromicaceous and chloritic schists and slates, exposed on the shores and islands of Ptarmigan Bay. The essential characters of this group are the predominance of hydromica and chlorite and the consequent soft, glossy fissile nature of the rocks. This breadth of three miles seems to be due to the duplication of the natural thickness of the group in a synclinal fold, so that, allowing for the dip, which is generally northward at high angles, its volume is estimated at about 7,500 feet. Thus we have, to the middle point of this belt of hydromicaceous and chloritic schists the following series:—

	FEET.
3. Hydromicaceous and chloritic schists and slates	7,500
2. Agglomerate-schists	7,650
1. Hornblende-schists	5,000
Total	20,150

Anticlinal of Labyrinth Bay.

Now if we turn to the granite boss of Labyrinth Bay, which, it has been pointed out, appears to lie in the axis of an anticline, and consider the sequence on either side of it, we find on the north side a breadth of half a mile of hornblende-schists and altered traps, mostly very chloritic and in a nearly vertical attitude. The true thickness of the formation can scarcely be ascertained at this point since it is interrupted and diminished by the granite intrusion, and is probably the only partially uncovered crest of an anticlinal fold. Further west, the breadth across the strike is about a mile, so that if the interpretation I have placed upon the structure as that of an anticline be correct, the formation has a thickness of at least half a mile or about 2,600 feet. Following this is a breadth of 1·3 mile of agglomerate-schists, which resemble in their character those of Clear-water Bay.

North side.

The dip throughout this bay is uniformly northward at high angles and the estimated thickness is about 6,600 feet. This is followed by the strata which constitute the southern half of the three-mile breadth of hydromicaceous and chloritic schists of Ptarmigan Bay. These were found to have a thickness of about 7,500 feet. Hence we have, reckoning from the centre of Labyrinth Bay anticline, the following series in ascending order:—

	FEET.
3. Hydromicaceous and chloritic schists and slates	7,500
2. Agglomerates	6,600
1. Hornblende-schists and traps	2,600
Total	16,700

To the south of the centre of the anticline we have the same sequence. In contact with the hornblende-schist group, where not interrupted by the granite boss, is a group of agglomerate-schists, dipping to the south, which have a thickness of about 2,400 ft. To the south of this we again find the hydromicaceous schists, though in considerably diminished volume. The schists dip south and their exposed breadth is about seven-eighths of a mile. This, however, appears to be (just as in the case of the similar rocks in Ptarmigan Bay) a synclinal duplication, and the real thickness as near as can be estimated is about 2,200 feet. Thus we have again the series:— South side.

	FEET.
2. Hydromicaceous schists	2,200
2. Agglomerate	2,400
1. Hornblende-schists and traps	2,600
Total	7,200

The series of granite irruptions, which I have described as stretching in an arch from the Yellow Girl granite mass in the heart of the Eastern Peninsula, to that which forms the nucleus of the Western Peninsula near Deadman Portage, is seen to be associated with an anticlinal arrangement of the strata. The line of section crosses this anticline midway between the south-east end of Labyrinth Bay and the bottom of Wiley Bay. The sequence on either side of the anticlinal axis is the same. The lowest member of the series, the group of hornblende-schists and traps, does not appear in its full volume here, but farther to the south-west it has a maximum thickness of 5,700 feet on either side of the Carl Bay granite, which lies in the line of the anticlinal axis. On the north side of the anticline the hornblende-schist group is followed by a group of agglomerate-schists which have a probable thickness of about 4,000 feet, and these are in turn in contact with the southern half of the synclinally folded group of hydromica and chloritic schists of Labyrinth Bay. Hence we have in ascending order:— Arrangement elsewhere on two sides of anticlinal.

	FEET.
3. Hydromicaceous schists	2,200
2. Agglomerate-schists	4,000
1. Hornblende-schists and traps	5,700
Total	11,900

On the south side of the anticline the hornblende-schists are followed by a breadth of a mile and a-half of agglomerate-schists, representing a thickness of 7,600 feet. These are in turn followed by a breadth of micaceous and hydromicaceous schists leaving a thickness of 3,800 feet on the line of section, although they appear to thin out rapidly to the south-west.

Here again, then, we have the same sequence in the series :—

	FEET.
3. Micaceous and hydromicaceous schists	3,800
2. Agglomerate-schists	7,600
1. Hornblende-schists and traps	5,700
Total	17,100

Synclinal at Big Narrows Island.

The attitude of the rocks around the Big Narrows Island granite mass is that of a syncline, the higher rocks being those in the immediate contact with the intrusion. Hence the sequence of the strata observed in approaching the granite along the line of section on either side is an ascending one. Now lying in contact with the micaceous and the hydromicaceous schists of the last series tabulated, is a considerable breadth of green, chloritic hornblende-schists and traps, with a generally southerly dip, though often quite vertical. These have a thickness along the line of section of 6,300 feet. These are followed by a band of agglomerate-schists, about 3,300 feet thick; and between these and the granite are mica-schists to a thickness of 1,530 feet. This gives us a series in ascending order analagous to the last, which it follows without any apparent stratigraphical break, thus :—

	FEET.
3. Mica-schists (quartzose)	1,500
2. Agglomerate-schists	3,300
1. Hornblende-schists and traps	6,300
Total	11,100

Going southward from the granite the same series is crossed in descending order. Thus we have first a band of mica-schists about 2,500 feet thick, then a band of agglomerate-schists which widens out rapidly to the west, but which, where cut by the line of section is not more than 1,500 feet thick. This is followed by hornblende-schists and traps, mixed somewhat with mica-schists, which have a thickness of about 2,500 feet. Tabulated the series is as follows:—

	FEET.
3. Mica-schists	2,500
2. Agglomerate-schists	1,500
1. Hornblende-schists and traps	2,500
Total	6,500

Southern border.

Between this series and the granitoid gneiss with which the belt is in contact to the south, the section shows only mica-schists and hornblende-schists, which may be arranged thus:—

	FEET.
3. Mica-schist	7,600
2. Agglomerate-schist (wanting)	
1. Hornblende-schist	3,500
Total	11,100

General three-fold arrangement.

Thus, reviewing the section as a whole we find in it what appears to be a very simple system of arrangement of its component groups of rocks. By arranging the different groups or formation of rocks in threes, and taking certain groups as common to two sets of threes, we have an eight-fold repetition of the same relations, with one exception due to the absence of a group. That is to say, we always get a combination of the three groups in which the agglomerate-schists occupy a middle position between the hornblende-schists and the mica- or hydromica-schists. The contact of the former with the granitoid gneisses, which are assumed to be the base of the whole, determines for it the lowest position in the series, and we have a definite sequence in ascending order of hornblende-schists, agglomerate-schists, and micaceous or hydromicaceous schists. If my interpretation of the folding of the strata be correct, this sequence is unvarying throughout this section of the belt. That interpretation will be gathered best from a consideration of the section C–D, where a restoration, in dotted lines, has been attempted of the original folded aspect of the belt. It may be described briefly thus:—

Number and arrangement of folds.

There are two anticlinal folds, crowded together in the central portion of the belt, with a common intermediate syncline, and wider synclines on either side, the outer flanks of which are in contact with the granitoid gneiss on the two parallel borders of the belt. This structure is not indicated so much by the dips of the strata as by the conditions attendant upon the granite irruptions, and the symmetrical arrangement of the strata on either side of the axis of such irruptions. A horizontal truncation of this double anticline, with the implied three synclines, such as denudation affords us on the natural surface of the ground, would shew a six-fold repetition of the vertical section of the series, as represented in the diagram at 1, 2, 3, 4, 5, 6.

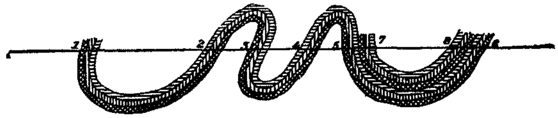


FIG. 12.—DIAGRAM ILLUSTRATING FOLDING OF KEEWATIN SERIES.

Eight-fold repetition in general section

We have, however, in the general section C–D an eight-fold repetition of the same apparent vertical sequence of groups. The two extra vertical sections (7 and 8) appear to belong to an upper or newer series of similar rocks, occupying the trough of the southern syncline of the lower series, in which the same groups of rocks have been deposited in the same order. These upper rocks would appear to form an integral portion of the general series of the rocks, so that in the sum of the two sub-series, the lower and upper, we have here a nearer approximation to the maximum development of the Keewatin series than elsewhere in the section C–D.

Total thickness of series.

If we take the average thickness of the three groups of rocks which enter into the composition, these lower and upper sub-series, as estimated from the six sections in the one case and the two in the other, and sum them, we arrive at a figure which may be regarded as an approximation, in a general way, to the average thickness of the entire series. Thus :—

		FEET.
Upper Sub-series.	6. Micaceous schist	2,000
	5. Agglomerate-schist	2,400
	4. Hornblende-schist and traps	4,400
Lower Sub-series.	3. Micaceous schist	5,133
	2. Agglomerate-schist	5,640
	1. Hornblende-schist	4,183
	Total average thickness	23,756

Description of Section A-B.

The section A–B, taken also transverse to the strike of the belt and lying from seven to ten miles west of the line of section C–D, presents many striking diversities from the stratigraphical arrangement displayed in the latter which has been assumed to be typical for the series in this region. It is chiefly interesting (1) in cutting across four large and important masses of intrusive granite; (2) in shewing a marked difference in the character of the strata which form the northern and southern halves of the belt; and (3) in showing both the north and south flanks of the belt dipping *under* the granitoid gneisses. In the southern half of the section, if we take the hornblende-schists and traps of Deadman Portage and those of the north shore of Falcon Island as the same formation, constituting the edges of a synclinal trough, in which the intermediate strata repose, in accordance with the interpretation placed upon the structure in the parallel section C–D, we find the sequence, as far as it can be traced satisfactorily, the same as that of the typical section. The basal group of hornblende-schists, which along the north shore of Falcon Island merges into a hornblendic schist-agglomerate, and dips under the granitoid gneiss, is but meagrely represented, and has a thickness of not much more than 600 feet. This

is followed by a wide band of agglomerate-schists, largely micaceous and quartzose, which have a thickness of about 7,400 feet. On the northern edge of this synclinal trough, the hornblende-schists and traps which form its edge, have a breadth of about 2,000 feet, but as they lie between two large masses of irruptive rock, the natural thickness of the formation cannot be satisfactorily estimated. The 2,000 feet of the same rocks that lie between the micro-granite irruptive mass, and the Carl Bay granite possibly form part of the same original thickness of strata, so that we would have a total apparent thickness of 4,000 feet. Following the hornblende-schists, just as on the south side of the trough, is a band of agglomerate-schists. The line of contact of the two has, however, in the vicinity of the section, served as the line of least resistance for the irruption of the Portage Bay granite, which thus separates them, and has evidently diminished the thickness of each. Thus far the sequence on either edge of the trough is the same and harmonizes with that found to hold generally in the section C–D. Beyond this the structure is less simple, and the central portion of the trough is occupied by a considerable breadth of mica-schists, fine-grained, evenly laminated, gray micaceous gneisses and agglomerate-schists, with some subordinate bands of green schists, the general stratigraphical relations of which cannot be satisfactorily determined, partly because the exposures are insufficient, being on scattered islands, and partly because these different rocks appear to merge into one another in such an intimate way that no hard lines of demarkation can be drawn between them. The *apparent* general arrangement of these rocks is given in the section, though in a very conventional way.

Central portion of section complicatad.

North of the vicinity of Deadman Portage the section is largely occupied by irruptive granite masses, and the country in this direction having been, either as a concomitant or consequent condition of such irruption, upheaved to a greater extent, it would appear that the upper rocks had been more extensively removed by denudation. Thus, between the granite mass of Carl Bay and the Canoe Lake mass, the only rocks met with are those which would appear to belong to the basal group of the series and are chiefly hornblende-schist, altered schistose traps and some massive diabases and diorites, with a few subordinate bands of mica-schist. These have a continuous south-easterly dip at high angles till within a short distance of the Carl Bay granite, where the attitude of the rocks is reversed, and the dip is away from the intrusion to the north-west. These rocks probably lie in a syncline between the two anticlinal axes represented by the Carl Bay and Canoe Lake granite masses. These same rocks completely surround the Canoe Lake granite mass and are seen to dip away from it on all sides wherever the dip is observable. On the north side

Section north of Deadman Portage.

Synclinal at Indian Bay granite.

of the granite and between it and the granitoid gneisses, with which the belt is in contact on its northern edge, the strata have the arrangement of a syncline. The sequence from the contact of the basal group with the granite on the one side, and from that with the granitoid gneiss on the other, is practically the same, to the middle of this portion of the belt, which is occupied by the Indian Bay granite mass. This granite thus appears to be quite analogous in its structural relations to that of Big Narrows Island, since both appear in the heart of synclinal folds, which are symmetrically situated with reference to the median anticlines of the belt, and to its northern and southern margins. The sequence presented in the section of this syncline, in the axis which has been irrupted the Indian Bay granite, is as follows:—

On the south side:

	FEET.
3. Hornblende-schists and altered schistose traps, merging in places into greenstone agglomerates, and with some bands of mica-schist	7,600
2. Finely fissile, soft hydromica and chloritic schists, with some bands of hard, glossy, white and nacreous sericite-schists—very silicious	3,800
1. Black-green hornblende-schists, and traps more or less schistose and decomposed	4,600
Total	16,000

On the north side:

	FEET.
3. Hornblende-schist and schistose traps	4,000
2. Hydromicaceous schists, with some silicious and felsitic schists and bands of agglomerate-schists which merge into boulder-conglomerate, in which the paste is a chloritic schist, and the pebbles, round or oval in shape, of pinkish, felsite rock, around which the cleavage of the schist curves	7,200
1. Hornblende-schists	5,000
Total	16,200

Thus not only is the descending sequence of the groups of rocks on either side of the Indian Bay granite mass the same, but the total thickness of the series is practically the same in the two sections.

Synclinal traced east and west.

The interpretation of the structure of the folded strata in this part of the section as that of a syncline, is strengthened very much if we trace out the lines of outcrop of the different groups east and west of the section. The band of hydromicaceous schists, which curves around the north and north-west sides of the Canoe Lake granite mass, as exposed on Echo Bay and the north shore of Shoal Lake, may be traced south-

ward, through scattered islands, for a distance of four miles from the latter place, retaining the same curvilinear strike, concave to the granite mass, and the same dip away from it. At this point, which may be regarded as the point of contact of the curves of upheaval concentric to the Canoe Lake granite mass on the one hand, and to the granitoid gneiss and granite of Snow-shoe and Rice Bays on the other, these hydromica-schists appear to stop abruptly. I conceive that here the strike doubles on itself, and trending off sharply to the north-west, the same rocks are represented in the micaceous schists which are observed on the islands between this and the entrance to Indian Bay and in Indian Bay itself. The band thus indicated by isolated exposures, has a general direction concave toward the Snow-shoe Bay granitoid gneiss, just as it has to the Canoe Lake mass. The schists differ considerably in their general aspect from those of the band described as curving around the Canoe Lake granite mass. They are black and micaceous, and pass into dark argillite slates. The stratigraphical identity of the two formations can, however, scarcely be doubted, inasmuch as at the bottom of Indian Bay these black mica-schists and slates converge with the band which has been taken as the analogue on the north side of the syncline of the first of the same two formations. Near their convergence the two bands have the same lithological characters. But the northern band, just as the southern does, appears, on being traced eastward, to merge into soft hydromicaceous and finely fissile chloritic schists, with minor bands of felsitic, silicious and agglomerate schists. Traced still farther east through Crow-duck Lake and Rush Bay, this same northern band of these schists is found in Ptarmigan Bay to be apparently confluent with the schists of the analogous band of the south side of the syncline. In this way the band of schists with which we are dealing would be convergent in three points, and the lines of outcrop have the shape of a curvilinear triangle, as in the diagram,

General form of outcrop of schistose belt.

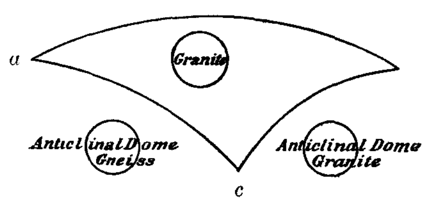


FIG. 13.—DIAGRAM ILLUSTRATING OUTCROP OF BAND OF SCHISTS.

where *a* and *b* are the points of convergence in the long axis of the synclinal fold, and *c* the convergence in the short axis between the anticlinal domes of the Canoe Lake granite and the Snow-shoe Bay

granitoid gneiss. This line of outcrop is thus simply the exposed edge of a basin or trough, in which lies the hornblendic and trappean schists through which protrudes the Indian Bay granite mass.

Description of Section E-F.

The section indicated on the map by the line E–F as traversing the Keewatin belt in a direction approximately parallel to its eastern limit, is of interest in showing the sequence and attitude of the strata on either side of the Yellow Girl granite mass, in its southern part; and in cutting the alternate, dove-tailed tongues of hornblende-schist and granitoid gneiss, in its northern part. The sequence of the rocks encountered in going north, across the strike, from the contact of the basal member of the series with the granitoid gneiss of White-fish Bay, is identical with that of the type section C–D, in the corresponding places, to within a short distance of the Yellow Girl granite mass. That is to say the hornblende-schists are followed by a group of mica-schists and micaceous slates, which are in turn followed by a band of hornblende-schists and traps and these again by agglomerate-schists.

Subdivision of basal group.

The basal group, which lies in contact with the gneisses, appears to be here susceptable of a threefold subdivision, viz., into (*a*) a sub-group of black, compact, hard hornblende-schists; (*b*) a great thickness of altered traps, more or less schistose as a rule, but often quite massive, constituting a second sub-group in ascending order, and (*c*) a sub-group of fissile green hornblendic and chloritic schists. In these three sub-groups we appear to have separated out in definite order, the rocks which usually are so intimately mixed in this group elsewhere; though the blacker and harder varieties of the hornblende-schists are apparently mostly confined to the neighborhood of the granitoid gneisses.

The general section, with the approximate thickness of the different members of the series, is here as follows:—

			FEET.
5.	Small, ill-defined bands of green schist, trap, mica-schist and agglomerate-schist		2,000
4.	Agglomerate-schists		800
3.	Hornblende-schists and traps		1,300
2.	Mica-schists and micaceous slates		4,700
1.	(*c*) Very fissile hornblendic and chloritic schists	3,800 feet	
	(*b*) Altered traps	4,200 "	
	(*a*) Black hornblende-schists	2,500 "	
			10,500
	Total thickness between granitoid gneiss and intrusive granite mass		19,300

The sub-divisions 1 to 4 present the same sequence as the section C–D, starting from the same line of contact about nine miles to the west.

The attitude of the rocks from 1 to 5 is that of continuous northerly-dipping series, at high angles, away from the granitoid gneiss. The brecciated character of the contact of the hornblende-schist with the granitoid gneiss, has already been described.

Contact with Yellow Girl granite to south.

In approaching the Yellow Girl granite mass from the south, the rocks appear to dip under the granite. When the actual contact is arrived at, however, there is sufficient exposure in certain places to shew that the beds really stand on edge on the granite with which they are more or less mixed after the fashion of a breccia. What is true of the strata at the immediate contact is probably indicative of the relations to the granite of those strata which outcrop on the surface at some distance from the granite, and I have therefore represented the latter as standing on edge on the granite in the section.

Rocks north of the granite.

On the north side of Yellow Girl granite mass the rocks dip away from the intrusion at high angles to the north. The section gives us an apparently ascending sequence as we go northward from the granite. There is crossed in succession a band each of mica-schist, hornblende-schist, grey compact felsite-schist and agglomerate-schist, and then we come upon the extensive development of hornblende-schists and altered traps which are in contact with the granitoid gneisses on the north-eastern confines of the belt, and are therefore regarded as basal. The second band away from the granite appears to be stratigraphically the same as this basal group, so that we have, in the neighborhood of the intrusion, a thickness of mica-schists lower than the formation which is usually basal. But these same mica-schists are also apparently the stratigraphical equivalent of the micaceous slates of the shore north of Yellow Girl, which are evidently higher than the hornblendic-schists. Hence it is very probable that the mica-schists which dip under the hornblende-schists on the section south of Witch Bay are in a locally inverted position, due to the disturbance caused by the intrusion of the granite, and that they with the micaceous slates and argillites of the shore north of Yellow Girl are on a horizon higher than the hornblende-schists.

Projecting tongues of basal members.

The basal group of schistose hornblende-rocks and altered traps is that which prevails to the exclusion of almost all other rocks throughout the north-eastern portion of the belt, which in this direction presents a serrated line of contact with the Laurentian gneiss, and sends out tongues apparently of a synclinal character into the gneissic area. Two of these tongues are cut by the line of section. The nature of the contact with the gneiss which is presented in the first of these, that at Pine Portage, has been alluded to in the description of the general contact features of the belt. The second tongue crosses the narrows of Black Sturgeon Lake, which affords a good natural section across the strike. The rocks

are chiefly hornblende-schists and display a synclinal structure, the dip on either side of the belt being inward, away from the gneiss, although at high angles.

SURFACE DISTRIBUTION OF THE KEEWATIN ROCKS.

Relative surface importance of various members.

Having now, by the consideration of these sections, indicated what appears to be the general structure of the belt, and the relations of the different groups of rocks which make up the whole series, I may refer briefly to the surface distribution of these groups so far as the character of the country renders the determination of this possible. The hornblende-schists and traps, which constitute the basal group of the series are the most extensively distributed of what remains to be seen at the present surface of the original Keewatin belt. This appears to be due partly to the more extensive removal by denudation of the upper members of the series, and partly to the fact that the latter were not laid down with that uniformity of distribution throughout the original trough, which seems to have been characteristic of the basal group. The next most prevalent rocks are the agglomerate-schists, which, as seen in one typical section C–D, occupy the second place in the ascending series; and last, though not differing much in this respect from the agglomerates, come the mica- and hydromica-schists and slates which are apparently at the top of the series as a general rule.

Subdivision into districts.

The distribution of the rocks about the outer edge of the belt having been indicated in the chapter on its contact with the surrounding gneisses, it will only be necessary to speak now of the rocks forming the inner part of the area. For this purpose it is convenient to consider the area in districts which are naturally more or less distinct from each other. These are as follows:—

1. District of Rat Portage and Big Stone Bay.
2. " Ptarmigan Bay.
3. " Shoal Lake.
4. " the Western Peninsula.
5. " the Eastern Peninsula.
6. " the Islands.

The Rat Portage and Big Stone Bay District.

The piers of the bridge by which the Canadian Pacific railway crosses the Winnipeg River, just above Hebe's Fall, rest upon traprock. This is but one exposure of an apparently continuous band of the same massive crystalline rock which runs for several miles

through the broader band of hornblende-schists, which is in contact to the north with the granitoid gneisses. This trappean band runs with the strike of the schists and was nowhere observed to be more than about fifteen chains wide. It is directly traceable in a series of ten or twelve satisfactory exposures for a distance of six miles, first along the ridge of rock that separates Darlington Bay from the Lake of the Woods and then beyond that into War-eagle Lake. When it crosses the railway track near the west end of Darlington Bay it is seen in the railway cutting to be very largely serpentinized, and the same modification of it is also found on the shores of War-eagle Lake. On the shores of Clear-water Bay, near the portage to Deception, the same dark crystalline trap is observed as a band in the same black hornblende-schists, and in the line of strike of the band when last seen on War-eagle Lake. A massive black, crystaline, finer-grained trap was also observed in the tongue of hornblende-schists which crosses the narrows of Black Sturgeon Lake, which is simply the continuation of those which cross the Winnipeg River near Rat Portage. Thus the trap is found in the same band of schists on the same line of strike for a distance of twenty miles. For six miles at least it is almost certainly a continuous band and it seems probable that it is continuous throughout the entire distance between its extreme known exposures. This rock appears to merge directly into the hornblende-schists which it traverses. In a few places it is possible to trace the transition in the texture of the rock from step to step, first as a tendency of the crystals to arrangement in a direction parallel to the strike of the schists without loss of granular texture; then, as a more decided parallelism, accompanied by a partial obscuration of the granular structure due apparently to a squeezing or pulling of the rock; and finally the assumption of a definite schistose structure, in which the original granular texture of the rock has been obliterated. In other places, as near the entrance to the tunnel on Tunnel Island, the contact of the trap and hornblende-schists does not present this transition, but is associated with the development of a somewhat ill-defined, intermediate border, or selvage, of very soft steatitic schist. Beyond its striking contact, as a massive rock, to the easily cleaving schists, I observed no breccia formation or dyke-like off-shoots, or other evidence indicative of an intrusive origin, and I am induced by its extensive line of outcrop in a line of strike coincident with that of the schists and that of their contact with the gneiss, and by its transitional passage with the schists themselves, to believe that it is an ancient trappean flow interbedded with the schists and coeval with them.

Important trap intercalation.

It seems further possible that this trap may be the original form of the whole band of hornblende-schists, and is revealed to us simply as

a remnant of the rock from which they have been derived under the combined influence of pressure and uralitic transformation of the chief constituent minerals.

Section contrasting with typical one.

The natural section afforded by the shore-line southward from the contact with the Laurentian gneiss at Hebe's Fall, shews the sequence of the strata in interesting contrast to that given by the section C–D. The basal group of hornblende-schist and trap, which dips northward under the gneiss at angles varying from 60° to 75°, has a thickness of about 1,500 feet. The character of the schist is by no means strictly uniform throughout this thickness. In some places it is very quartzose, hard and slaty, as in the rock-cutting nearest the town of Rat Portage; in others it is softer, more hornblendic and greener in color, and characterized by the development of asbestus along planes of apparent slickensiding, which are roughly parallel with the planes of rock cleavage; in other places the schists shew the presence of considerable quantities of brownish-black mica in very fine scales, so that they would here be better described as micaceo-hornblende-schists. Following these hornblende-schists in ascending order is a breadth of about half a mile of mica-schists, mostly very quartzose, and merging, by the addition of feldspar, into gray, finely laminated gneissic schists, or gneisses. This group represents a thickness of approximately 2,500 feet of strata. The rocks dip continuously to the north at angles rarely, if ever, lower than 75°. In places they are intensely crumpled, as if there had been a strong doubling-up pressure acting in a direction parallel to the strike, in addition to the ordinary transverse pressure. Beyond the contrast in the lithological character of the rocks, there is no evidence of a stratigraphical break between the hornblende-schists and this superimposed group of mica-schists and finely laminated gray gneisses, the latter following the former in perfectly conformable sequence. These schists underlie a large portion of the town of Rat Portage, and are fairly well exposed on the shore as far southward as the creek which drains into the lake at the Rainy Lake Lumbering Co.'s mill. They are also well exposed on the railway behind the town in various cuts and natural exposures. Westward of Rat Portage they occupy the northern end of Coney Island, and form the south shore of Tunnel Island and of the ridge which separates the Lake of the Woods from Darlington Bay. A couple of chains to the south of the Rainy Lake Lumbering Co.'s mill, at the mouth of the creek, this group of micaceous and gneissic schists is in contact with a breadth of a quarter of a mile of bedded traps, hornblendic and chloritic schists, representing a thickness of about 1,300 feet. These rocks run across Coney Island, and occur on other islands to the west of it as far as the west shore, where they are

Rocks at Rat Portage.

found in contact with the lower mica-schist band, just as they are at the mill near Rat Portage. At the Coney Island Narrows the group is followed by a thickness of probably 1,500 feet of agglomerate-schists, the clastic nature of which has been determined by microscopic examination (p. 53 C C.)

These agglomerate-schists are extensively developed on the south side of Coney Island, but they appear to be essentially a lenticular band, since they neither occur on the railway in the line of strike to the north-east nor westward on the west shore of the bay. They are probably the representatives of the enormous development of agglomerate-schists which occupy the north shore of Clear-water Bay. Following the agglomerate-schists, on the shore-line between Rat Portage and the Devil's Gap, is a thickness of about 2,000 feet of hornblende-schists of a comparatively black and slaty aspect. These have a continuous southerly dip, although the strike swings around from N. 80° E. to N. 55° E. Between this band and the Devil's Gap the rocks are greener hornblendic schists and schistose traps, both often quite chloritic. Intermixed with these are occasional small bands of mica-schists and slates, whose relations to them, whether as intercalated beds or as pinched-in folds, are quite undefined. The strikes of the rocks here twist about somewhat erratically from N. 55° E. to S. 75° E., and the exposures are not such as to allow of these being traced out in detail. A small patch of these slates, associated with some felspathic schists, probably clastic, occur at the entrance to the Devil's Gap, on the west side. They have a strike of N. 80° E., and dip vertically. South of these the section through the Devil's Gap shews only massive, fine-grained, dark-green rocks, a typical specimen of which has been determined by Mr. Bayley to be an altered trap. These rocks are most massive at the north end of the Gap, and in going southward across the strike, which, as far as can be determined, is about N. 80° E., they gradually assume a roughly schistose character, and finally, at the south end of the Gap, appear to merge, across the strike, into chloritic schists. **Rocks near Devil's Gap.**

These chloritic schists are cut on the east side of the south end of the Gap by an intrusive mass of hard, compact, moderately fine-grained, fresh trap, which is of much later date than the other rocks of the vicinity. The presence of this trap in the line of the long, straight, fissure-like water-route which runs from the Winnipeg River southward by way of Coney Island Narrows and the Devil's Gap, suggests that that route lies in a line of faulting. There is, however, little real evidence in support of such a supposition. Southward and eastward from the Devil's Gap, the main shore of the lake is made up almost entirely of rocks similar to those in the Gap. They appear to **Trap dyke.**

be to a large extent altered traps, of massive aspect and little or no indication of bedding, associated with more or less chloritic hornblende-schists and smaller, vein-like bands of dark, glossy, green schists, with a peculiar crumpled cleavage, which appear in most cases to be altogether chloritic, although sometimes they are largely epidotic, when they show a greenish-yellow colour in patches. These bands of dark-green, crumpled, chloritic schists vary in width, as a rule, from two to twenty yards, and traverse the more massive compact rocks in such a way that I am induced to consider them as derived by processes of mineralogical decomposition from the latter. They merge directly into the rocks they traverse, and would appear to have been developed from them by aqueous percolation along planes of separation, which are either the partings of an original bedding, or are fissures of subsequent date. These chloritic bands are often characterised by the presence of quartz veins and stringers, and occasional natural vertical sections shew the quartz veins to have an irregular zig-zag course through the schists. The presence of these quartz veins clearly points to these chloritic bands having been channels of ready percolation, and although the veins are not present in a very large number of those observed, yet, considering their passage into the adjacent rock on either side, and their limited width, it appears altogether probable that they are not bedded strata, but have originated in the way suggested.

Mode of production of chloritic bands.

Hydromica-schists.

Beyond the hornblende-trap and chloritic schists, the only other rocks met with between the Devil's Gap and Pine Point are some narrow bands of hydromica-schist and a narrow band of mica-schist. The hydromica-schists appear on either side of the peninsula which terminates in Brulé Point. On the west side they appear as comparatively fresh, whitish to nacreous, very fissile sericite-schists, having a strike of N. 64° E. and a dip to the north-west at high angles. Those on the west side of the peninsula skirt its east shore with a strike of N. 54° E. and dip to the south-east. These schists, though somewhat more decomposed and chloritic than those on the west side, are doubtless the same rocks, and the divergence of their dip is suggestive of an anticlinal structure, the axis of which is coincident with the middle line through the peninsula. These narrow bands, it is to be observed, are but the tapering northward extensions of the large development of hydromica-schists which prevails in the Northern Peninsula and on Scotty, Middle and Hay Islands. The band of mica-schists referred to occurs on the east side of Bald Indian Bay, near the Quarry Island gneiss. The band cannot be traced for any distance, and has no apparent connection with similar rocks elsewhere.

On the east side of Pine Point the same massive green schists prevail as to the west. On the east side of Pine Portage Bay, however, there is an interesting occurrence of a considerable thickness of fissile, dark-green hornblende-schists. These occupy the whole breadth of Heenan Point, and extend from its extremity to beyond the bottom of Pine Portage Bay. Their general strike varies from N. 15° E. to N. 30° E., and is practically identical with the direction of the long axis of Heenan Point. The dip is about vertical. They cross Bigstone Bay, and form the rock of the opposing Needle Point on Hay Island. At the base of Needle Point the band appears to double on itself, since the same schists appear farther east on the north side of Hay Island with a strike which converges rapidly towards that of the schists of Needle Point. The dip of the schists of Needle Point is eastward, and that of those which converge upon them is to the northwest, so that the attitude of these two converging bands of similar schists presents all the aspects of a syncline. The schists which thus occupy Heenan Point and Needle Point are essentially hornblendic, but very much decomposed, and thus characterized by the presence of large quantities of chloritic material and the segregation of calcite or or dolomite and quartz. The calcite resulting from the decomposition of the silicate has often separated in such a way as to form an almost gneissic interlamination with the hornblendic and chloritic constituents of the rock, presenting a distinct alternate banding of white and green. The quartz has segregated in irregular stringers, and is not infrequently characterized by the presence of beautiful radiating bunches of black tourmaline needles.

Hornblendic schists.

These schists in their general characters resemble closely those which have been described as the uppermost sub-group (*c*) of the basal group of hornblendic schists and traps cut by the Section E–F between White-fish Bay and Yellow Girl Bay; and they appear to occupy an analagous place stratigraphically with reference to the more massive lower members of the group. Their relatively higher position in the group of hornblende-schists and traps so extensively developed in the Big-stone Bay district, is indicated by their lying in the central portion of the Pine Portage syncline. Their place in the heart of the syncline is interesting in a consideration of the origin of schistose structure or rock cleavage in general. If, as seems to be generally true, schistose structure is due to the influence of pressure upon rocks, we should naturally expect to find the rocks most schistose in those positions where we have reason to believe the greatest pressure was exerted. Now, in the cores of synclinal and anticlinal folds the pressure must have been much greater than that exerted on their flanks, by reason of the leverage afforded by the rocks themselves. It is,

Origin of schistose structure.

therefore, an interesting confirmation of the theory of the causal relations of pressure and schistosity to find, as in the present instance, the more fissile rocks in the heart of a synclinal fold.

Rocks of Big-stone Bay. The shores and islands of Big-stone Bay east of Needle and Heenan Points are almost entirely composed of massive greenish-black, feebly schistose hornblende-rocks, such as that microscopically described as Section 13, and more or less schistose altered traps, with not a few of those narrow vein-like bands of crumpled chloritic schists already alluded to. These rocks form the greater portion of Hay Island, and the shores of the lake around to the base of Pipe-stone Point. Their distribution is limited to the south-west, however, by their coming in contact on the south side of Hay Island and on Middle Island with a higher group of hydromicaceous magnesian and chloritic schists, which curve sharply around the more massive rocks of Hay Island, as if they formed the flanks of a truncated anticline. The strike of these schists on the south side of Hay and Middle Islands varies from due east to S. 80° E., and they form a band which appears to run through Pipe-stone Point, as a narrow tapering infold in the massive green rocks. The average strike of the same schists on Middle Island is about N. 40° E., so that the general trends of the two spurs of the bifurcation which thus embraces the rocks of Hay Island, converge at the south-west corner of Middle Island. From this point the rocks have a common strike across the lake of west-south-west.

Stratigraphical difficulties. The mapping of the distribution of the rocks and the general relations of the hydromica group to the hornblendic group as a higher member of the series, point very distinctly to a anticlinal structure. The dip of the schists in the two branches of the bifurcation, however, although always at high angles, is that of a syncline. It is a difficult matter to reconcile this synclinal dip with the other anticlinal conditions that appear to hold, unless we call to our aid the assumption of a marked unconformity between the hornblendic rocks of Hay Island and the hydromicaceous group of schists. The more massive character of the rocks of Hay Island and the Hades Islands renders the determination of their trend and dip (if they be stratified at all), very unsatisfactory and in themselves afford little evidence bearing upon the question of the conformability or the reverse of the two groups. Such traces of stratification as are observable, however, appear to indicate that the planes of the latter are coincident with those of the overlying group of hydromicaceous magnesian and chloritic schists. These fissile schists pass by gradations on the west side of Middle Island, into more massive agglomerate-schists, which here present a considerable breadth, and on Scotty Island run in two parallel bands apparently interbedded with the hydromica-schists.

The north end of Scotty Island is occupied by green hornblendic, trappean and chloritic schists. On the south-west of Scotty Island the schists are cut transversely by a large dyke of granular trap. This dyke is in the line of strike of, and probably identical with, a large dyke of similar trap, 180 feet wide, which cuts the schists of Thompson Island across its entire breadth. This dyke is probably of the same age as that at the south end of the Devil's Gap. On the south-east side of Thompson Island the dyke was observed to be fine-grained in the neighborhood of its contact with the schists and to become very much coarser grained towards the centre, where, also, a certain proportion of quartz was detected which was not visible in the same rock nearer the dyke walls. **Trap dyke.**

An inference can be drawn, as to the condition of the rock as a magma at the time of its injection, from the fact, that those portions of the schist wall, which were broken off and formed, with the intruded rock, a contact breccia, have not travelled far through the magma from their original places of rest. Instances, such as that illustrated in the accompanying figure, where blocks of included schist are seen to **Contact phenomena of trap.**

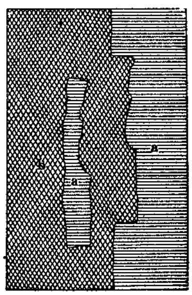


FIG. 14.—CONTACT OF DYKE WITH SCHIST WALLS, THOMPSON ISLAND.

have moved only a short distance from their origin, indicate that the magma axis must have been comparatively thick and viscid.

Another dyke of the same trap was found cutting the schists on the main shore a little over a mile and a-half west of Point Aylmer.

In the natural section presented by the west shore of Rat Portage Bay from Keewatin to Point Aylmer, the higher members of the series are much more strongly represented than on the opposite shore from Rat Portage to the bottom of Big-stone Bay. Following the band of micaceous and gray gneissic schists, which have been alluded to as occurring in the north-west corner of the bay, in the same relative position as the same schist at Rat Portage, there is to the south-west a band of green hornblendic and trappean schists three-eighths of a mile **Rocks of Rat Portage Bay.**

wide. These are followed by a breadth of half a mile of micaceous and gneissic schists comprising a narrow band of black carbonaceous schists, the whole having a general strike of about N. 80° E. or N. 85° E. and a more or less vertical dip. To the south of these the shore is occupied for a mile and a-quarter, in a straight line, by green hornblendic and trappean schists. The strike of these is from S. 80° E. to S. 75° E. and the dip varies but little from the vertical either way. In the islands off shore these schists appear to pass into agglomerate-schists, which are probably the continuation of the lenticular band of agglomerates that presents its strongest development at Coney Island Narrows and on the south side of Coney Island. The next mile and three-quarters of this shore, measured in a direct line, is occupied almost altogether by soft, fissile, green to gray and glossy hydromica and chloritic schists. The strike of these schists varies from N. 85° E. to S. 75° E., and the dip, when not vertical, is to the north at high angles. They appear at the north end of Poplar Bay, and cross the peninsula with the same general breadth to Clear-water Bay on the west side. The shore to the east of these fissile schists as far as Dispute Point and the opposite shore of Tangle Island, together with the shores and islands about the entrance to Poplar Bay, between Dispute Point and Point Aylmer, are of rather massive green schists, through which, in their extension south-westward, a granite boss protrudes. In the neighborhood of Dispute Point there appear, running through these schists, bands of a ferruginous dolomite varying from a foot or so to twenty feet in width. This and other dolomites, as I have stated elsewhere, appear to be segregated masses and not interstratified beds. On the north side of Tangle Island and the south-east end of Treaty Island there are bands of micaceous schists which, since they are in the same line of strike as the hydromicaceous and micaceous schists of the main shore, are probably the representatives of the latter diminished in volume in this direction. The greater part of Treaty Island is composed of the same massive green rocks as are exposed in the Devil's Gap, and described as altered traps, with subordinate bands of chloritic schists. Port Aylmer is composed of coarse agglomerate-schists. The east and west sides of Thompson Island are occupied by very fissile hydromica- and chlorite-schists, while through its central portion there appears to run a band of massive green schists of the altered trap variety.

The Ptarmigan Bay District.

The predominating rocks in the Ptarmigan Bay District are agglomerate-schists, hydromicaceous and chloritic schists and micaceous slates.

Clear-water Bay is eroded out of a wide band of the first of these rocks, which is well exposed along nearly the whole of its northern shore and a considerable part of its southern. These schists at the east end of the bay (*i. e.*, part north of the entrance to White Partridge Bay), are of the character of greenstone-agglomerates. Westward of this, however, they merge into micaceous and finely laminated, fine-grained, grey, gneissic, agglomerate-schists, and towards McCallum Point the agglomerate characters become so feeble that the schists are often, in bands, simply mica-schist. The continuation of this band on the shore opposite McCallum's Point is represented by schists which are mostly micaceous and show little or none of the characteristic appearance of the agglomerates, though obviously of the same stratigraphical formation. The agglomerates on the south side of the bay, which form so large a part of Zig-zag Point, are less micaceous and more of the character of greenstones than on the north side, merging into bands of hornblendic and chloritic schists on the one hand and into felsitic schists on the other.

Preponderating rocks.

The basal bands of hornblende- and trap-schists described as occupying a large part of the west side of Rat Portage Bay, does not come through to Clear-water Bay, but thins off rapidly to a wedge between the Clear-water Bay agglomerates and the next band to the south, of micaceous and hydromicaceous schists and slates, which are thus, by the disappearance of the intermediate band, allowed to come in contact. These micaceous and hydromicaceous schists cross the peninsula from the west shore of Rat Portage Bay, and form the prevailing rock on the shores of White Partridge Bay, which affords almost continuous exposures of them throughout its length. They occupy the greater part of the northern peninsula and Cork-screw Island, which they cross in a broad band with a strike varying from N. 80° E. to S. 80° E. The dip, as a rule, varies but little from the vertical. In the natural section afforded by the channel to the east side of Cork-screw Island, however, the dip is seen in the northern portion of the band to be to the north, while southward, towards Spruce Point, it inclines to the south, giving the strata the aspect of an anticlinal fold. Those portions of the band which occupy the shores of White Partridge Bay are more micaceous and slaty than the schists farther southward, which are chiefly glossy, grey to nacreous hydromica-schists, with bands of soft, fissile, green, chloritic schists. The north side of the east-and-west trending portion of the channel, which lies east of Cork-screw Island, exposes a considerable extent of an apparently lenticular band of agglomerate-schists which crosses the channel to Cork-screw Island, but does not appear on its west side. This lenticular band of agglomerate-schists is to be regarded stratigraphically as an integral portion

Hornblendic rocks and trap-schists.

Rocks on White Partridge Bay, etc.

of the hydromicaceous group of schists rather than as the crest of a return fold of the Clear-water Bay agglomerates. Westward of Cork-screw Island the hydromicaceous schists continue across Ptarmigan Bay with the same general strike, but are seen on the islands of the bay and on the south side of Zig-zag Point to be strongly interbanded with hornblendic, altered trappean and chloritic schists. At the west end of Ptarmigan Bay these schists bifurcate and form two diverging bands, one trending through Echo Bay and then curving southward around the Canoe Lake granite mass, and the other, striking westward, is traceable by excellent exposures along Rush Bay into Crow-duck Lake. In Crow-duck Lake the schists are frequently intercalated with narrow bands of agglomerate-schists, and often pass into hard, whitish, felsitic schists. Associated with the hydromicaceous group of schists, although not altogether confined to them, are a number of small but very interesting bands of carbonaceous schists. The general character of these has already been described, but the localities where these bands are exposed, on the shores of Ptarmigan Bay, may be noted. On the south side of Wood-chuck Bay, (the western end of Clear-water Bay), at a point about a mile west of Mud Portage, the agglomerate-schists, which are there the prevailing rock, are interbedded with small bands of fissile micaceous and hydromicaceous schists. In one of these latter bands is a small thickness of black carbonaceous schists. It is difficult to say what the precise thickness is, as the shore makes but a small angle with the strike at the particular place of exposure, but it does not appear to exceed fifteen or twenty feet. The strike is N. 80° E. and the dip north at very high angles.

Carbonaceous schists.

Two miles and a-half east of Mud Portage, on the north side of Zig-zag Point, there occurs another smaller band of the same schists under similar conditions. The strike is about the same as in the last case, and the dip is vertical. Another band of black carbonaceous schists was observed interbedded with a fine-grained, grey, apparently clastic slate, on the north side of Cork-screw Island, near its north-eastern extremity. The slates are associated with mica-schists of a black, slaty character, the general strike being S. 80° E. and the dip not appreciably varying from the vertical. On the south side of Zig-zag Point, about midway between Mud Portage and the extremity of the point, a band of carbonaceous schists, of small width, with a strike of N. 75° E. and north-westerly dip, occurs in black, slaty, micaceous schists. The same band has been exposed by prospectors three-quarters of a mile eastward along the line of strike. Half way between this and the extremity of Zig-zag Point another band, about twenty feet wide, outcrops on the shore with a strike of N. 65° E. and south-easterly dip, interbedded in schists similar to the last. This band may possibly be

identical with the last and lie in the return of a local synclinal fold. On the south-west end of Cork-screw Island, about half a mile north of the narrows between this and Copper Island, a bank of carbonaceous schists, not more than ten feet wide, runs through the hydromica-schists, into which, by a diminution of the proportion of carbonaceous matter, they merge on either side. The strike is S. 80° E. and dip north $< 80°$.

The only other feature of special prominence, revealed by an examination of the rocks along the tortuous shores of Ptarmigan Bay, is the development of a large band of agglomerate-schists in the vicinity of Ash Bay. In its general outlines this band is lenticular in shape, its maximum breadth lying in the line of section C–D. As may be seen by that section it is regarded as stratigraphically identical with the Clear-water Bay agglomerate-schist band. Westward of Ash Bay the band tapers off rapidly, interfolded with the underlying group of hornblende-schists and altered traps. Eastward it also tapers off somewhat abruptly, so far as can be judged from the islands of the bay, but is traceable in a more attenuated band to near the entrance to Ptarmigan Bay and is represented still further to the north-east by the agglomerate-schists of Hare and Wolf Islands.

Shoal Lake District.

The more interesting geological features of this part of the area have been described more or less at length in those parts of the report which deal with the confines of the area, the granite masses, and the line of section A–B, so that there remains little of importance to which attention should be directed. A few explanatory allusions may, however, be made to some of the features represented on the map, which have not hitherto been referred to.

Isolated patches of agglomerate-schists.

There occur on the shores and islands of Shoal Lake, a number of isolated patches of agglomerate-schists which appear in some cases to be the remnants of once continuous bands, now nearly altogether surrounded by denudation, and in others to be merely local developments of the formation, on horizons occupied as a rule by other rocks, into which it merges. The eastern extension of Cash Island is composed of a rather massive greenstone agglomerate-schist, no representative of which is found on the north shore of this lake in the continuprojection of the line of strike. Felix Island, about a mile to the north of this, is also composed of these agglomerate rocks.

Passage into trap-schists.

There are a number of patches of the same rocks in the neighborhood of the Indian Bay Narrows, which merge into altered trap-schists, of a massive character. Although represented on the map in different

colours from the trap-schists, they appear to be of the same stratigraphical formation as the latter. A number of the islands opposite the mouth of Hell-diver Bay are composed of agglomerate-schists which are probably the representatives of the band which runs from Crow Rock Channel across to the south end of Labyrinth Bay and westward. The shores of the Shoal Lake Narrows and Labyrinth Bay are interesting in presenting the most extensive exposures of serpentine rocks that have been observed in the region. They are intimately associated with more or less schistose altered traps, which are extremely calcareous and effervesce freely with dilute acid. It would be difficult to map the exact distribution of these serpentine rocks without making a very detailed examination of the ground, and their relations to the surrounding rocks. Although they do not appear as dykes or afford much satisfactory evidence of irruptive origin, it is probable that such is their character, and that they are the altered representatives of intrusions of olivine-bearing rocks of later date than the Keewatin series.

Serpentine rocks.

Association.

The association of the very calcareous trap-schists and the serpentines is interesting, since both are profoundly altered rocks, and the result of mineralogical disintegration and re-composition along different lines of chemical relation in rocks of orignally different constitution, although the former is an essential part of the Keewatin series, and the latter probably intrusive through the series.

Schists on west side Shoal Lake

The group of schists in contact with the granitoid gneiss on the west side of Shoal Lake, require perhaps a few words of description supplementary to the map. These schists have a strongly marked stratified aspect, and are composed for the most part of quartz and mica. In the immediate vicinity of the granitoid gneiss, however, there is present a considerable proportion of black hornblende, and the rock presents, to a feebly-marked extend an agglomerate appearance. In many places there is a considerable proportion of feldspar present in the rocks where they pass into gray, fine-grained, evenly laminated gneisses. The micaceous and quartzose minerals, however, preponderate, and give character to the rocks of the group as a whole. Towards the eastern margin of the band, in the vicinity of Rabbit Point, there are interstratifications of green hornblendic schists, and on the south side of Gull Bay, the band is seen to be followed conformably to the eastward by a breadth of green hornblendic and altered trap-schists. A mile or so farther southward these are in contact, on the extreme east of the shore, with a band of black, slaty mica-schists, of unknown width. Beyond Berry Point there are no exposures at the south end of the lake, except a boss of diorite that projects through the sand about a mile east of the Hay River.

The Western Peninsula.

The general character and relation of the strata which occupy the northern portion of the Western Peninsula have been given in the account of the line of section C–D, and the same has been done for the rocks in the vicinity of Deadman Portage, in the account of the granite, and of the section A–B. Southward toward the North-west Angle Inlet, the rocks within the interior of the peninsula are more or less unexposed or unaccessible, so that their actual distribution has not been satisfactorily determined, and the mapping is only such as appears most probable from the observations made along the shores.

The probable stratigraphical identity of the more or less gneissic mica-schists, which dip away from an undefined extent of granitoid gneiss, on the south-east side of Shoal Lake, with the mica-schist dipping away from the granitoid gneisses, at the mouth of the North-west Angle Inlet, has been pointed out. Following these schists along the shore to the north of the mouth of the inlet is a band of hornblende-schists, nearly three-quarters of a mile in breadth, which passes in its central part into agglomerate-schists. The dip of these schists is at first coincident with the mica-schists to the south of them, but within a short distance from the contact the dip changes and inclines to the south, but as in both directions it is at angles higher than 75°, little can be inferred from the change as to the structure of the strata. The general strike of the schists along the shore is from S. 70° W. to due west, so that the projection of this band westward in the line of strike would cause it to converge with the central band of hornblende-schists that occupies the axis of the peninsula. This convergence of the strike, indicating a curving around of the axial band of hornblende-schists, so as to cause them to appear on this shore, is quite in harmony with the similar convergence of the mica-schists which lie between the hornblende-schists and the granitoid gneiss. Along the same shore the hornblende-schist band is followed by a band, three-quarters of a mile wide, of southward-dipping agglomerate-schists. These are mostly micaceous and quartzose, and pass on their northern margin directly into gray, gneissic, mica-schists. This band, in accordance with what appears to be the relations of the strata to the south of it, can only be the return of the band of agglomerate-schists, which is so largely developed on the north side of Monument Bay, as a continuation of the band which runs from Wiley Bay, and strikes in towards the centre of the peninsula, at the west end of Monument Bay. Finally, the great breadth of hornblende-schist and altered traps which occupies the south side of Monument Bay and the shore to the south of it, would appear to be a synclinal duplication of the band of similar rocks, which trends along the east

Gnessic mica-schists.

Hornblende- and agglomerate-schists.

Synclinal duplication on Monument Bay

side of the peninsula, and is chiefly developed in the islands between the Big Narrows Island and main shore. This band is in more or less direct continuity, as will be seen from the map, with the north half of the schists on the south side of Monument Bay, so that their southern half would be the equivalent of the band of the same rocks cut by the section C–D, about a mile south of Big Narrows Island, according to the interpretation placed upon the attitude of the strata along that line.

The shores of the peninsula, from the bottom of Shoal Lake on the one side, and the North-west Angle Inlet on the other, north to its extremity at Brulé Point, afford excellent and continuous exposures of the rocks, so that the map itself and the observations recorded upon it, give the most concise account of the natural sections of the strata of which it is composed.

The Eastern Peninsula.

Anticlinal structure.

The anticlinal character of the Eastern Peninsula is well illustrated in a transverse section taken across the peninsula and islands in the vicinity of Bottle Bay. In the axial line of the peninsula is an elongated mass of irruptive granite, and on either side of this, the sequence of the rocks is the same, and they dip away from the irruption at higher angles. On the north side the succession is as follows:—

1. Massive green schists, hornblendic and altered traps. 2. Grey felsitic schists, merging into agglomerate to the north. 3. Agglomerate-schist.	Dip north.

On the south side we have:—

1. Massive green schists, as before. 2. Yellowish felsitic schists with clear quartz grains, merging into agglomerates to the north. 3. Agglomerate-schists.	Dip south.

Intercalated clay-slates.

Farther south, between this line of section and Yellow Girl Point, a a considerable thickness of more or less micaceous clay-slate intervenes between the green schists and the felsitic schists, so largely developed on Shore Island. There same slates, often quite massive and devoid of slaty cleavage, but nevertheless undoubted argilites, occur near the granite at Yellow Girl Point, and at the immediate contact appear as glossy-black micaceous slates, the differentiation being due, doubtless, to contact metamorphism. These slates are probably stratigraphically identical with the band of mica-schists observed in contact with the same granite mass on the bush traverse from the east end of Witch Bay. Here the mica-schists dip under the hornblende-schists, but owing to the disturbance due to the irruption, this is probably a locally inverted

dip, and the schists are really superimposed upon the green hornblendic schists, constituting with the slates of the shore north of Yellow Girl Point, a development of partially altered sediments, which would thus occupy the same horizon as the similar micaceous schists and clay-slate of the east end of Yellow Girl Bay, and the more quartzose mica-schists exposed along the greater part of the Adams River. The felsitic schists of Shore Island, and the bay to the north of Yellow Girl Point, appear to lie in a trough of these slates.

The other more prominent geological featnres of the peninsula have been already touched upon in former parts of the report.

The Islands.

Connection established between peninsulas by the islands.

Among the more interesting stratigraphical features revealed by the exposures on the islands of the lake, is the connection that is established between the anticlines of the Eastern and Western Peninsulas by the belt of islands extending from French Narrows to Crow Rock Channel. This connection will be best understood by an examination of the map. The dip of the rocks on these islands varies but little from the vertical, and ordinary anticlinal divergence of the dip is not often observable, so that taken by themselves the structural relations of the strata composing these islands is not very apparent. Taken, however, in connection with the structure of the peninsulas, between which they form a chain of connection, as it were, those relations become plain. Generally speaking, the central portions of the islands are rather massive hornblendic schists and altered traps, through which have been irrupted a series of granites or micro-granites, while to both the north and south of this median band lie broad belts of agglomerate-schists. This relationship is the same as that on the main shore at Crow Rock Channel and at the extremity of the Eastern Peninsula, and as the islands are in the same curved line of strike as the rocks at those points, their geological structure is undoubtedly the same. The agglomerate-schists on the north side of this belt of islands, form the connecting link between the agglomerate-schists of Crow Rock Channel and those of Andrew Bay, so that these rocks may be said to extend in a continuous band from the Shoal Lake Narrows to the east end of Witch Bay, a distance of over twenty-five miles. The general strike of this band is a curve concave to the south, the radius of the curve being about thirty miles.

The agglomerate-schists of the south side of Crow Rock Island, Allie Island and numerous other islands indicate clearly the continuation of the band of similar rocks which runs north-eastward from Monument Bay, past Portage Bay to Wiley Bay on the main

shore. This band trends in an almost semicircular curve from Portage Bay to within half a mile of Yellow Girl Point, the curve being as before concave to the south, with a radius of about fifteen miles. On Fog Island, near Yellow Girl Point, this band of agglomerate-schists is seen to turn on itself and trend off westward in a direction diverging from the previous strike by 60.° The strike can be traced bending through this angle and the dip of the whole is synclinal so that we have here undoubtedly the end of a synclinal fold. The southern spur of the syncline cannot be traced far, since it runs under the waters of the lake.

Glacial Phenomena.*

General character of glaciation.

The Lake of the Woods region is profoundly glaciated. Indeed, it may be correctly regarded, as has been previously stated, as a partially flooded region of *roches moutonnées.* Everywhere the rocks display unmistakable evidence of the polishing and grooving effects of the passage of detritus-laden ice over the surface of the country. The flow of the ice, as indicated by the direction of the groovings, has been from north-east to south-west. This, it is to be observed, is not strictly coincident with the strike of the rocks. This general or average strike of the rocks is more of an E. N. E. and W. S. W. direction, and as a matter of observation, it appears to be generally true that it is the strike of the rocks, rather than the direction of the ice flow, that has determined the direction of the long axes of the *roches moutonnées.* The direction of the ice flow from north-east to south-west is probably that of the general dip or slope of the surface of the country over which the ice passed, and this appears to have exerted a more powerful directional influence upon the moving ice than the trend of the ridges of the country. The *roches moutonnées* are, if we regard the surface of the Lake as a base of reference, of all sizes from mere rounded hummocks to large islands over one hundred feet high. They are best exposed on the northern aspects, while the southern is usually more or less concealed by heaps of drift, chiefly boulders, that appear to have been dropped by the ice immediately after its passage over the obstruction. This talus of boulders upon the southern slopes of the rounded rocks of the country is a feature of considerable constancy so far as observed. Northerly or north-easterly facing

Distribution of boulders and drift.

* As stated in the introductory portion of this report, the general character of the glaciation and distribution of the drift on the Lake of the Woods, has been pretty fully treated by Dr. G. M. Dawson. See Geology and Resources of the Forty-ninth Parallel, Chap. IX. and Quart. Journ. Geol. Soc., Nov., 1885.

shores are, as a rule, bold and rocky, while those facing the south present much more limited rock exposures and low bouldery beaches. The contrast is readily observable on many of the islands and channels of the lake. Of these may be cited by way of example Hay Island, whose northern aspect is abrupt and rocky, while on its south side it is characterized by considerable stretches of boulder-strewn shores. The same is true of Middle and Scotty Islands, which are more or less pointed to the north and have low shores on their south side. Boulders are far more abundant upon the north and south-west shores of the Eastern Peninsula than upon its northern shore, which is abrupt and rocky. The south and south-west shores of the Northern Peninsula are more or less strewn with drift. The south shores of Big Narrows Island, Falcon Island, Birch Island are all more or less strewn with boulders, which are almost entirely wanting upon their northern shores. The same contrast is observable in east-and-west trending bays and lakes. Crow-duck Lake has a precipitous south shore and a lower sloping more or less drift-covered northern shore. The peninsula which separates Indian Bay from Snow-shoe Bay is more rocky and abrupt on the north side than on the south, which is more or less strewn with drift except on the projecting points. The north shore of Long Bay is thickly strewn with boulders and the shore is low and sloping as a rule, while the south shore of the Bay is precipitous and rocky. Instances might be multiplied, but these will suffice to illustrate a principle that seems to prevail in the distribution of the drift.

Drift of northern part of lake.

The northern portion of the lake is characterized by a general absence of the finer kinds of drift, sand and clay deposits are rare, and the drift is composed almost entirely of more or less rounded fragments of rocks of Archæan origin. The largest boulders sometimes attain a size of fifteen feet cube, and from six to ten feet cube is not unfrequently met with. These larger boulders are usually angular and are composed of either granite or granitoid gneiss. The smaller boulders, those of an average diameter of a foot or less, are generally quite rounded. In the southern part of the lake the drift is of an essentially different character from that of the northern portion, both in the abundance of the finer kinds of drift of a sandy nature, and in the character of the erratic blocks themselves. In addition to the erratics of Archæan origin, fragments of a buff or cream-colored fossiliferous limestone of Cambro-Silurian or Silurian age, are more or less thickly strewn about its shores. Occasional small pebbles of this limestone are found in the northern part of the lake as far north as Rat Portage, in gravel deposits. But apart from such small fragments, these limestone erratics are a peculiar feature of the southern portion of the lake, a fact first observed by Dr. J. J. Bigsby. Dr. G. M. Dawson has

Drift of southern part of lake.

suggested a number of possible explanations of the occurrence of this limestone drift and its confinement to the southern portion of the lake. He conjectures the possible existence of a limestone floor for this portion of the lake, which may be now either concealed or may have been removed by glacial action; considers the possibility of the limestone being derived from the Hudson Bay area of fossiliferous rocks, and finally regards as the most probable explanation, a process of translation from the similar beds of the Red River valley, by means of floating ice at the close of the glacial epoch.

Origin of limestone drift. Recently discovered glacial striæ on the polished surface of the flat-lying rocks of the Red River valley which have a north-west and south-east course, as well as the prevalence of such striæ or groovings in eastern Minnesota, and the striation occasionally detected on the Lake of the Woods in a direction transverse to the general ice flow,* point to an ice stream of later date than the north-east and south-west moving glaciers, which probably set in from the high lands which bound the first prairie steppe to the west. This stream, coming down the valley of Lake Manitoba and Lake Winnipegosis from the east flanks of the elevations now represented by the Porcupine Hills and the Duck and Riding Mountains, would cross Manitoba in the direction indicated by the striation of the rocks at Stony Mountain †, at Stonewall ‡ and at Black Bear Island, Lake Winnipeg §.

The close similarity of the limestone drift of the southern portion of the Lake of the Woods with the bedded limestones of Manitoba, lends strong support to the explanation indicated by these glacial groovings.

The following is a record of the directions of the glacial groovings and striæ, so far as observed by myself and assistants, upon the Lake of the Woods and vicinity:—

LIST OF DIRECTIONS OF GLACIAL GROOVINGS AND STRIÆ.

Bottom of Pine Portage Bay	S. 40° W.
Pine Portage Bay, east side	S. 35° W.
Heenan Point	S. 11° W.
Point Aylmer	S. 47° W.
"	S. 15° W.
Rat Portage Bay, west side	S. 27° W.
War-eagle Lake, south side	S. 55° W.

*See Geology and Resources of the Forty-ninth Parallel, p. 206.

† Manitoba Historical and Scientific Society Trans. No. 15, 1884-5. "Gleanings from outcrops of Silurian strata in the Red River valley by J. Hoyes Panton, M. A., pp. 7 and 8.

‡ Id. p. 11.

§ Id. Trans. No. 20, 1886, "Notes on the Geology of some islands in Lake Winnipeg" by J. Hoyes Panton, M. A., p. 5.

Small lake, north of Crow-duck Lake	S. 55° W.
Channel S. W. of Cork-screw Island	S. 40° W.
Island off north shore Cork-screw Island	S. 47° W.
" " " " "	S. 50° W.
Island west of last	S. 55° W.
Bay on west side of Cork-screw Island	S. 50° W.
Island east of Zig-zag Point	S. 52° W.
South side Zig-zag Point	S. 45° W.
Mud Portage Bay	S. 54° W.
Island in Ptarmigan Bay, south of Mud Portage	S. 55° W.
Island at mouth of Rush Bay	S. 52° W.
Island in Rush Bay	S. 57° W.
Echo Bay, west end	S. 54° W.
Island off S. W. end of Copper Island	S. 54° W.
Copper Island, south side	S. 42° W.
Cork-screw Island, south side	S. 52° W.
Island in Ptarmigan Bay, 2 miles west of Brulé Point	S. 50° W.
Ptarmigan Bay, south side	S. 50° W.
Island south of Brulé Point	S. 50° W.
Island, 1½ miles S. E. of Brulé Point	S. 45° W.
Shore, 1¼ miles south of Brulé Point	S. 45° W.
Fox Island, north shore	S. 42° W.
Wolf Island, S. E. side	S. 44° W.
Scotty Island	S. 45° W.
Small island off east side of Scotty Island	S. 35° W.
Largest of the Hades Islands, west side	S. 45° W.
Same island at another place	S. 45° W.
West side of Hay Island	S. 25° W.
" " to the north of last	S. 30° W.
Island off south shore of Middle Island	S. 30° W.
Extremity of Pipe-stone Point	S. 42° W.
Pipe-stone Point, near extremity, south side	S. 46° W.
" " east of last	S. 47° W.
" " north side	S. 43° W.
Island off north side of Pipe-stone Point	S. 40° W.
South shore, Witch Bay	S. 50° W.
" Witch Bay, ¾ mile farther west	S. 45° W.
" Witch Bay, ¼ mile west of last	S. 50° W.
" Andrew Bay	S. 50° W.
A mile and a-half east of French Narrows	S. 42° W.
Two miles S. E. of French Narrows	S. 30° W.
Shore, 2½ miles S. E. of French Narrows	S. 37° W.
Island half-way between French Narrows and Yellow Girl Point	S. 53° W.
Island 3¼ miles N. W. of Yellow Girl Point	S. 40° W.
Island south of Ferrier Island	S. 43° W.
South-west side of Shore Island	S. 45° W.
Half a mile S. E. of last	S. 45° W.
Yellow Girl Point	S. 47° W.
Island south of Yellow Girl Point	S. 53° W.

Rat Lake, west end	S. 42° W.
" same rock surface as last	S. 60° W.
" east end	S. 44° W.
End Lake	S. 45° W.
Island in Yellow Girl Bay	S. 47° W.
Same rock surface as last	S. 56° W.
South shore, Yellow Girl Bay	S. 50° W.
" Yellow Girl Bay, 1 mile east of point	S. 48° W.
Mouth of Black River	S. 52° W.
A mile and a-half south of Black River	S. 50° W.
Rendezvous Point	S. 45° W.
South shore, Long Bay, 1¼ mile east of Rendezvous Point	S. 48° W.
North shore, Long Bay, 2½ " " "	S. 45° W.
Mist Inlet, near mouth	S. 45° W.
" north end	S. 45° W.
North shore, Long Bay, 6 miles east of Rendezvous Point	S. 41° W.
South side, " 5½ " " "	S. 42° W.
" " 7 " " "	S. 45° W.
" " 8 " " "	S. 35° W.
Island in Long Bay, 8 " " "	S. 35° W.
North shore, " 7 " " "	S. 37° W.
" " 7½ " " "	S. 43° W.
" " 8 " " "	S. 42° W.
East end of Long Bay at Reed Narrows	S. 40° W.
Hudson Bay Co's. Post, White-fish Bay	S. 43° W.
Island in Sioux Narrows	S. 42° W.
South side, Sioux Narrows	S. 34° W.
Sioux Narrows	S. 40° W.
North Shore White-fish Bay, near passage	S. 42° W.
Shore two miles south of Yellow Girl Point	S. 65° W.
Island 1½ miles W. S. W. of Yellow Girl Point	S. 45° W.
North-west corner of Chisholm Island	S. 40° W.
Island north of east end of Cliff Island	S. 45° W.
Island north of Cliff Island	S. 50° W.
Shore of Grande Presqu'île, 5½ miles east of Mud Lake	S. 50° W.
" " " 4½ " " "	S. 45° W.
Island north-west end Cliff Island	S. 53° W.
Island south of Mouse Island	S. 45° W.
Gull Island	S. 50° W.
Island north of Gull Island	S. 45° W.
Island 1 mile north of Gull Island	S. 42° W.
Island 2 miles north of Gull Island	S. 42° W.
Island 2½ miles S. E. of Infernal Point	S. 50° W.
Island 1½ miles S. W. of Rope Island	S. 45° W.
South side of Infernal Point	S. 50° W.
Shore north of Crow Rock Channel	S. 37° W.
Island half a mile S. W. of Crow Rock Channel	S. 49° W.
North side Wiley Bay	S. 50° W.
South side Wiley Bay	S. 46° W.
Shore one mile S. W. of Wiley Point	S. 50° W.

Bottom of bay south of Wiley Point	S. 50° W.
Island one mile S. S. W. of Wiley Point	S. 54° W.
Island two miles east of Wiley Point	S. 48° W.
Island 1½ miles S. E. of Wiley Point	S. 45° W.
Island 1¾ mile S. E. of Wiley Point	S. 53° W.
North side Rope Island	S. 48° W.
East end Rope Island	S. 55° W.
North-east end of Kennedy Island	S. 55° W.
North shore of Kennedy Island	S. 50° W.
" " " same rock surface as last	S. 65° W.
Island north of Kennedy Island	S. 55° W.
Island east of Big Narrows Island	S. 52° W.
South-east side of Kennedy Island	S. 52° W.
West side of Kennedy Island	S. 55° W.
North side, east end of Big Narrows Island	S. 43° W.
North side Big Narrows Island	S. 51° W.
Island north of Big Narrows Island	S. 53° W.
Small Island north of Big Narrows Island	S. 54° W.
Shore, 2¾ miles S. W. of Wiley Point	S. 43. W.
North shore Big Narrows Island	S. 46° W.
" Big Narrows Island	S. 47° W.
North-west shore Big Narrows Island	S. 53° W.
" " " same rock surface as last	S. 85° W.
Island in the Big Narrows	S. 48° W.
" "	S. 49° W.
" " the same rock surface as last	S. 45° W.
North-west shore of Big Narrows Island	S. 46° W.
" " "	S. 55° W.
South shore of Big Narrows Island	S. 55° W.
South-west end of Big Narrows Island	S. 43° W.
Island at south end of the Big Narrows	S. 52° W.
Main shore of the Big Narrows	S. 35° W.
Shore 1¼ miles south of Picture Point	S. 45° W.
South-east end of Labyrinth Bay	S. 48° W.
South side Labyrinth Bay	S. 45° W.
Large Island in Labyrinth Bay	S. 50° W.
Island opposite mouth of Hell-diver Bay	S. 42° W.
Shoal Lake, north shore	S. 47° W.
" "	S. 45° W.
East side Indian Bay, Shoal Lake	S. 50° W.
North side Indian Bay, Shoal Lake	S. 52° W.
Island off south shore, Indian Bay	S. 45° W.
Shoal Lake, east side	S. 45° W.
Small island, south of Wood-chuck Island	S. 40° W.
Island 2¼ miles south of French Portage	S. 22″ W.
East side Tug channel	S. 40° W.
" "	S. 44° W.
East side of Falcon Island	S. 45° W.
" "	S. 40° W.
South-east side of Birch Island	S. 50° W.

South-west side of Cyclone Island	S. 35° W.
Small island west of Passage Island	S. 50° W.
Sabascosing Bay	S. 34° W.
Island south of Sabascosing Bay	S. 25° W.
Island ¾ mile S. E. of Starting Point	S. 40° W.
Island 1¼ mile S. S. E. of Starting Point	S. 38° W.
Island 3 miles N. W. of Sand Point	S. 50° W.
Shore 1½ miles north of Sand Point	S. 35° W.
Shore ¾ mile N. E. of Sand Point	S. 43° W.
Large island west of Sand Point	S. 50° W.
Same shore as last, further west	S. 50° W.
South-west corner of Dog Island	S. 38° W.
North-east corner of Rubber Island	S. 48° W.
Mouth of Morton Bay	S. 42° W.
North end of Miles Bay	S. 32° W.
North-east shore of Miles Bay	S. 35° W.
Island off north shore of Big Island	S. 40° W.
North-east side of Big Island	S. 32° W.
South-east side of Big Island	S. 20° W.
" "	S. 37° W.
" " same rock surface as last	S. 75° W.
" " half mile from last	S. 35° W.
West side of Big Island	S. 32° W.
Massacre Island	S. 42° W.
Island 1½ mile W. N. W. of north end of Bear Island	S. 40° W.
Island south of Oak Island	S. 38° W.
Louis Inlet (White-fish Bay)	S. 42° W.
Narrows Point "	S. 25° W.
Cat Point "	S. 18° W.
Steamboat Island, "	S. 40° W.
Squaw Island "	S. 40° W.
Bell Island "	S. 40° W.
Turtle Portage "	S. 30° W.

The following list of observations for the direction of the glacial striæ is given by Dr. G. M. Dawson, in his report on the "Geology and Resources of the Forty-ninth Parallel." The list is reproduced here, so that, taken with my own observations in the same and other portions of this region, the record may be as complete as possible. The bearings have been corrected for the magnetic variations to bring them into correspondence with the preceding.

North-west Angle Inlet.

McKay Island	S. 58° W. to S. 60° W.
Bucketé Island	S. 45° W.
North shore	S. 49° W.

South-westward from N. W. Angle Inlet.

Flag Island Point	S. 50° W.
" " "	S. 37° W.
" " "	S. 52° W.

Southern Promontory.

North-east Point	S. 33° W. S. 70° W. S. 35° W. S. 10° W. S. 65° W.
Cormorant rock	S. 33° W.

North of Rainy River (Mainland.)

	S. 22″ W.
	S. 40° W.
Windy Point	S. 30° W.

Bigsby Island.

South end of	S. 37° W.
" "	S. 40° W.
" "	S. 30° W.
West side of	S. 80° W. & S. 20° W.
" "	S. 83° W. & S. 33° W.

Middle Island (?)

East side of	S. 15° W.
" "	S. 23° W.
North end of	S. 35° W.

North Island.

	S. 40° W.

North shore SandHill Lake, District of Shebashca.
(South side of the Grande Presqu'isle)

	S. 35° W.
	S. 50° W.
	S. 45° W.
	S. 44° W.
	S. 35° W.
	S. 30° W.
	S. 35° W.

Northward from N. W. Angle to Rat Portage.

	S. 40° W.
	S. 46° W.
The Small Promontory	S. 45° W.
	S. 43° W.
	S. 33° W.
	S. 42° W.
	S. 50° W.
	S. 40° W.
	S. 43° W.
	S. 49° W.
	S. 52° W.
	S. 63° W.
	S. 55° W.
	S. 58° W.
	S. 50° W.
	S. 48° W.
	S. 45° W.
	S. 45° W.
	S. 52° W.
	S. 42° W.
	S. 37° W.
	S. 40° W.
	S. 50° W.
	S. 48° W.
	S. 30° W.
Lacrosse Island (Scotty Island.)	S. 37° W.
" "	S. 50° W.
	S. 45° W.
	S. 45° W.
	S. 32° W.
	S. 27° W.
	S. 25° W.
	S. 30° W.
Rat Portage	S. 35° W.
Rat Portage Fall	S. 23° W.
" " (Winnipeg side)	S. 26° W.

General direction of the movement.

From these lists it will be observed that the great majority of the striæ have directions that lie between S. 35° W. and S. 55° W. About 18 per cent. of the observations shew the striæ to have a course outside of these limits. Of these, 13 per cent. have directions less than S. 35° W. and 5 per cent. greater than S. 55° W. The general average is about S. 45° W., or true north-east and south-west as the mean direction of the ice flow across the Lake of the Woods. The groovings, which are beyond the general limits of S. 35° W. to S. 55° W. may be regarded for the most part as abnormal local

digressions of the ice current, although in some instances, in the southern part of the lake, where one set of striæ is almost transverse to the usual set, the former seem to be due to a distinct and probably later ice current, as suggested by Dr. Dawson.

Later transverse striation

That post-glacial agencies other than those of the waters of the present lake have been engaged in the re-arrangement and stratification of the drift material there is abundant evidence. On the level of the railway track, a little to the east of Rossland, the gravel pit shews the following section of an old lacustrine deposit:—

Stratified deposit near Rossland.

1. Two feet (from surface) of fine, light yellow, sandy soil, with some vegetable loam and roots penetrating through it.
2. Eight inches finely bedded white and brown, extremely fine, almost impalpable sand, hardened and difficult to break with the fingers, with some inch and inch and a-half beds of coarser sand. Bedding, wavy.
3. Thin layer of white, calcareous matter, with roots and fragments of stems imbedded in it.
4. Same as No. 2, four to seven inches.
5. Same as No. 3.
6. Same as No. 2, four inches.
7. Same as No. 3.
8. Bedded, coarse reddish sand, eight inches.
9. Same as No. 8. but showing well-marked false bedding.
10. Coarse reddish sand, with large and small boulders, the whole shewing only feeble or no traces of stratification.

On Corn-field Island no hard rocks are exposed, but sections afforded by the shore shew a bedded gravel in which limestone pebbles are abundant, conformably resting upon compact, somewhat hardened bedded clays. Gravels and sands of the same character, in the same relative position, are exposed extensively on the Rainy River. The stratiform arrangement of this drift, due to post-glacial agencies, was not observed on islands or shores of the lake north of Corn-field Island and that noted at Rossland is on a much higher level. The stratified gravels and clays of the southern portion of the lake and Rainy River coincide approximately in their northern extension with the distribution of the limestone erratics, and with the northern line of the low sand-covered shores, and it appears not improbable that the line which defines the northward extension of all these, viz., the abundance of the finer kinds of drift, the limestone erratics and the stratiform arrangement of the clays and gravels, is the shore line at one of its most pronounced stages of a post-glacial sheet of water, the same with the hypothetical Lake Agassiz, which seems to have spread over so large a portion of this part of the continant, and left so many old beaches as

Drift deposits of southern lake.

the proof of its existence. If this supposition be well founded, then the Lake of the Woods, or at least its southern portion, is but a remnant of that much larger lake, and its drainage was consequently at one time by the south, till its southern end became dammed by deposits of sand.* Ice barriers may have constituted the northern shores of this immense lake, and in this case we would have an adequate explanation of the absence in considerable quantities of the finer drift, and of the absence of stratiform arrangement of the drift in the northern portion of the lake, since, by the time the ice had receded from this part, the waters may have subsided to too low a level to have covered the northern portion.

Notes on Economic Resources.

Gold.

Mr. Coste's Report.

In the last Report of Progress, for 1882–4, Mr. E. Coste gives the result of his observations upon the occurrence of gold in the Lake of the Woods district, and upon the state of the gold mining industry at the time of his visit in 1883. Since his report was written, the condition of affairs has changed but little, and no real advancement has been made in any of the enterprises he describes, although the more sanguine and energetic prospectors continue to make discoveries, and bring in from the bush and the lake shores specimens of ore shewing free gold in quantities which are exceedingly encouraging, and which do much to sustain the belief of those who best know it that the Lake of the Woods is yet destined to become a permanent field for profitable mining enterprise. A few words will serve to supplement Mr. Coste's account of the state of the industry, and bring the history of the more important ventures to date. Since 1883, the Manitoba Consolidated mine has not been worked, and the adjoining Argyle mine has been equally unproductive. The proprietors of the latter, becoming apparently convinced of the inadvisability of further prosecuting the development of their location, have during the past season (1885) stripped the mill of its machinery and abandoned their works. Prior to this the mill had, in 1884, been employed in crushing a quantity of ore brought to it in barges from the Keewatin mine on Hay Island. These two mines were the only ones of any importance in the Clearwater Bay district, and their abandonment has destroyed the sanguine views that were lately entertained for the future of the district,

Clear-water Bay district.

* For additional facts bearing on this point see Geology and Resources of the Forty-ninth Parallel, pp. 217, 254.

and relegated it to a position of merely historic interest. A considerable number of exploratory pits to the depth of a few feet have been sunk on leads in various parts of this district, particularly in Echo Bay, the south side of Zig-zag Point, at Mr. Kendall's place at the east end of Clear-water Bay, and at Thompson's at the west end, but none of these seem to have as yet warranted more serious outlay than a few blasts and the assay of the ore thus secured.

Big-stone Bay district.

In the Big-stone Bay district, however, the state of affairs is more hopeful.

Pine Portage mine.

The Pine Portage mine, the most important and most promising venture in the district, was worked steadily throughout the summer of 1884, there being about a dozen hands employed. The shaft was sunk to a depth of 100 feet, and a drift run to a considerable distance to the south. The ore was milled as it was taken from the shaft. In 1885 very little work was done at the mine, but it is, I believe, the intention to continue operations during the coming season, the aspect of the vein and the character of the ore being fairly constant so far as developed, and warranting the vigorous prosecution of the enterprise. The reason assigned for the suspension of work is largely the difficulty encountered on the part of the proprietors in securing a thoroughly competent and experienced mining engineer to take charge of the operations of the mine, and their reluctance, in the light of experience, to enter upon any further serious outlay till such a manager can be procured. The position taken by the proprietors of the Pine Portage mine is a sound one, but one that brings into prominence the fact that in Canada or the adjoining States there are extremely few practically trained mining men, who, in addition to their knowledge of the economic management of the works and mine, possess also a scientific comprehension of the problems concerned in the extraction of the gold, which will enable them to study to advantage the milling of new ores such as these, and devise methods of treatment for particular cases which will preclude serious loss in the "tailings," such as has been the aggravating experience at the Pine Portage mine.

Keewatin mine

In 1884 a gang of men was employed for a considerable portion of the summer in mining, or rather quarrying, quartz from the lead of the Keewatin mine, at the point where it comes out upon the shore of Hay Island. The ore was shipped in barges to the stamp mill of the Argyle mine, where it was crushed. The lead seemed to carry considerable quantities of free gold, the crushed rock from drill holes almost invariably showing a very perceptible "colour" when washed. This work was done on the lead described by Mr. Coste as the "second vein" of the Keewatin mine. The exposure thus effected did not

serve to demonstrate a more definite character for the vein than that given by Mr. Coste, the quartz seemingly ramifying in various directions from a main mass or vein. In 1885 no work that I am aware of was done on this location. These two locations are the only ones that have been regularly worked for any considerable period since the time of Mr. Coste's visit. Preparations were being made in the autumn of 1885 for the resuming of work at the Winnipeg Consolidated mine.

Winnipeg Consolidated mine.

Prospecting.

While actual mining has thus advanced but little during the last two years, prospecting has been active and has resulted in promising finds. The best of these have been in the country to the east of Big-stone Bay and on an island in Yellow Girl Bay, where Mr. Moore found a lead, the upper decomposed earthy cap of which yielded me a fine shew of gold on washing. A number of specimens of quartz carrying visible gold have also been brought in from time to time by prospectors from the country to the east and south end of Big-stone Bay.

Position of Big-stone Bay deposits.

From what has been already observed by Mr. Coste regarding the disposition of the lines of veining in the neighborhood of Big-stone Bay, and from the geological features that I have sine been able to work out, a well-defined relation seems to be established between that disposition and the line of contact of the schistose hornblende-rocks, in which the veins occur, with the granitoid gneiss of the Laurentian.

Directions of veins.

Mr. Coste found the majority of the veins in this district to trend approximately either north-and-south or east-and-west and was disposed to classify them on this basis as probably due to two distinct systems of fissures, those of meridianal strike being of the most pronounced and well-defined characters. My own observations on the geological relations of these veins lead me to differ somewhat from this view, as regards at least some of the more important veins, which seem to me, although differing widely in their strike to be genetically associated, and to belong to a common system of veining. The Pine Portage lead is a fissure cutting a hard, massive schistose hornblende-rock (Section No. 12, p. 38 cc), at a distance of only 150 feet from a granite mass towards which it dips. The lead is parallel to the contact of schist and granite. The latter is part of the great granitic and gneissic Laurentian area to the east. This line of contact has been traced, as shown on the map, from its nearly north-and-south trend at the Pine Portage mine to the more nearly east-and-west strike which it assumes as it runs thence to the north of Big-stone Bay. The line is associated, to a greater or less extent, both to the west of Pine Portage, and to the east as far as the neighborhood of the Winnipeg Consolidated location on the south side, with quartz veins of a minor character, which are seen on the shores of the northern exten-

Conditions at Pine Portage mine.

sions of Big-stone Bay, and whose strikes are for the most part, though not always, coincident in direction with that of the line of contact. The larger veins of the Winnipig Consolidated, Lake of the Woods Mining Co., Bull-dog and other locations is a continuation of this intermittent line of quartz-filled fissures, which, although showing a north-and-south strike at Pine Portage mine and a nearly east-and-west strike at the east end of Big-stone Bay, belong to one and the same system, characterized by proximity to, and parallism with, the line of contact of the schists with the acidic and feldspathic rocks to the north and east. That line of contact is, as I have shewn in a previous portion of this report, eminently an igneous and brecciated one, the gneissic rocks having been in a soft and plastic condition in which were imbedded angular fragments of the schist and which penetrated the schist as injected dykes.

Reasons for believing the veins a single system.

This association of a system of auriferous quartz leads with a line of igneous or granite contact is one of peculiar scientific interest. For the miner and prospector it is enough to know that there is such an association. To make it a guide in the search for auriferous veins in new fields would doubtless lead to promising discoveries.

A guide to the prospecter.

The dip of the Pine Portage vein towards the granite mass at so short a distance to the east of it, is a feature of the mine that may develop interesting facts as the work proceeds. It is extremely difficult to discover whether the granite actually occupies an inferior position to the schist or the reverse. If the former is the case the shaft, if continued at its present incline in the vein, would strike the contact of the schist and granite at no great depth, and the analogy of some of the most successful mines would warrant the presumption of a concentration of metallic material in the neighborhood of the contact of two such diverse rocks, with the juxtaposition of which is so evidently associated the existence of the lead.

Silver, Copper, &c.

Silver.

Silver occurs in the auriferous quartz veins of the Lake of the Woods, generally as an accessory mineral, in small quantities, but sometimes, as the assays of the ore of the Pine Portage mine show, in greater proportions by weight than the gold. No leads sufficiently rich in silver ore to be mined for that metal have as yet been discovered.

Copper.

Copper pyrite is of very common occurrence in leads of quartz both of those that have been mined for gold and those that have not warranted such operations. It is not found, however, in sufficient quantities to be worked as an ore for copper, and the likelihood of copper mining becoming an industry here is a matter to be determined very largely as yet by the discoveries of the prospector.

Iron.

Deposits of iron ore have not been found as yet on the lake, although a large proportion of the rocks is very rich in disseminated magnetite. Magnetic sand, derived from the decomposition of the Laurention gneiss, occurs on the west side of Falcon Island, in stratified layers, which have evidently been so arranged by the sifting action of the waves on the beach, separating out the heavy magnetite from the light, silicious and feldspathic grains. The line of separation between the black magnetic sand and the light yellow sand is a very distinct one, and the percentage of magnetite in the former is large, but the deposit is an extremely recent one and the abundance of the magnetic sand is not such as to be of economic importance.

Other metallic minerals.

Zinc-blende and galena are not uncommon in such quartz veins as have been opened, and I have found both in small quantities in different parts of the district.

Molybdenite occurs in small veinules traversing the granitoid gneiss of Quarry Island, and I have been given large specimens of the same mineral said to have been found in the bush between Rossland and the Lake of the Woods.

Antimony ore is said to have been found in Ptarmigan Bay, but not so far as I could ascertain in any considerable quantity.

Cobalt is found to occur in traces. Mispickel and iron pyrite are comparatively abundant in veins of various dimensions, the larger of which may prove of value should the manufacture of arsenic and sulphuric acid ever become profitable in this part of the country.

Limestone.

Good limestone for the manufacture of lime for building purposes is an article of considerable local demand at Rat Portage and vicinity, and as the place increases in importance, either as a mining or a milling centre, or both, the necessity for a constant supply of this material at a moderate price will become more urgent. Up to the present no local source of supply has been utilized, so far as I am aware, and such quantities as have been absolutely needful have been brought as quick-lime from Winnipeg. The increase of price thus due to carriage has been a deterrent to its use in the building of the houses of the town, which are chiefly of wood, unplastered inside, and so less substantial, less comfortable, and more liable to destruction by fire than they otherwise would be. In view of the necessity for a supply of limestone for local purposes, I have been careful to note the occurrence of any limestones or dolomites that might be rendered available for the purpose.

There are two distinct sources from which limestone may be procured on the Lake of the Woods:—(1.) The numerous cream-colored, magnesian, limestone boulders that so thickly strew portions of the shore of the southern part of the lake. (2.) The vein-like deposits of crystalline dolomite found among the schists of the northern part of the lake.

Sources of limestone.

Without reverting to the question of the probable source of the former, it may be stated that it burns to a lime of good properties, and is, in fact, precisely the same limestone that is burned at different points on the Red River. In Minnesota, to the south of the Lake of the Woods, this source of limestone is largely used, and it is found there that these drift boulders make the finest lime. Several thousand bushels are made annually in the western part of the state. Drift limestone is also used extensively in Iowa and Illinois for the manufacture of lime. There is no reason why that found on the islands and shore in the southern portion of the lake and on the Rainy River, where it is of common occurrence, might not be gathered and brought to a kiln at Rat Portage at less expense than the quarrying of the stone in place would entail, and thus not only supply the district with quick-lime at a moderate figure, but also add in a small though very practical way to the industries of the town.

Drift limestone.

The limestones of the second class are found in limited quantities at different points on the shore and islands of the Lake of the Woods. They are generally of a dirty yellowish color on fresh fracture, and have the composition of a ferruginous dolomite, with more or less silicious matter, which detracts from the value of the lime. These dolomites are easily recognized by their deep brownish-yellow, ocherous weathering, due to the formation on the exposed surface of the hydrated oxide of the iron which is contained in the rock, probably as carbonate. When obtained moderately free from quartz it would make a fairly good lime after the necessary conditions of burning, such as duration of firing, etc, had been ascertained by trial on the large scale. One specimen of this ocherous-weathering, yellowish dolomite from Dispute Point was found on examination to contain only 6·5 per cent. insoluble matter, and is, therefore, for all economic purposes, a remarkably pure dolomite, though more or less ferruginous. Most of the exposures of this dolomite shew it, however, to be more quartzose, with the exception of one large vein-like deposit on the north side of Gaherty Island, about nine miles south of Rat Portage, where it was found to be very free from visible quartz. As there appears to be some doubt in the minds of those interested in the matter as to whether dolomite will make as good a lime as a pure non-magnesian limestone, it may be as well to quote the opinion on this subject of Prof. N. H.

Dolomite veins.

Opinion of Prof. Winchell.

Winchell, State Geologist of Minnesota, who has made a special study of the relative merits of the various building materials of that State: "The lime that is made from magnesian limestones or dolomites differs from pure lime, both in composition and in its action when used. It was formerly supposed that the presence of a considerable per cent. of magnesia was detrimental to lime, and it used to be the aim of lime-burners to avoid such stones and seek for the pure limestones, or those that contained about 90 per cent. of carbonate of lime. But it has been found that the presence of magnesia, while probably actually reducing the quickly cementing quality of the lime, yet gives it that moderateness of slacking and setting which really makes it more useful in the hands of masons, and also prevents the waste and loss that arises from the immediate setting of pure limes. The magnesian limestones burn easier, the presence of the magnesia acting to disseminate the heat more perfectly through the whole than can be done with pure calcitic limestones, and also in some way apparently causing a granular, and often a vesicular, texture to pervade them, which allows the penetration of the heat within and the quick expulsion of the carbonic acid. As they burn more easily, so they slack more slowly, and with less heat evolved. They set more slowly also. This last quality is what makes them more useful than the pure limes. With a single spreading of mortar several bricks can be laid before the lime sets, but with pure lime but two or three bricks can be laid. This quality is especially desirable in plastering where some time is required in rubbing and smoothing the surface."

Supposed limestone.

A specimen from the north shore of Shoal Lake, which was apparently free from ferruginous and silicious matter, and of a gray color and finely granular texture, presenting the physical and chemical character of a limestone by the ordinary tests, was found to contain 68·6 per cent. of insoluble material, probably magnesian schists, which would cause it to approximate to soapstone in composition, although its hardness was much higher than that of the latter rock. Such a stone is, of course, totally unfit for purposes of lime-making.

Granite.

Different classes of granite.

A very large proportion of the more costly or ornamental building stones of the future cities of Manitoba and the North-west will undoubtedly come from the area of crystalline rocks which limits the prairie to the east and north-east. In this connection it is interesting to know that in the Lake of the Woods district there is an inexhaustable supply of good granite, in fine variety both as regards colour and texture. Both in the true granites and in the granitoid gneisses the

shades vary from very light gray to deep red, the latter color, however, being more characteristic of those granites to which a distinctly intrusive origin may be assigned than to the granitoid gneiss. On Quarry Island and elsewhere the gray granitoid gneisses have been quarried for blocks for bridge piers with very satisfactory results. The areas of intrusive granite are prominently coloured in carmine on the accompanying map. But although these granites are well distributed throughout the district and easy accessible by water, it is altogether probable that those exposures of granitoid gneiss found at intervals along the line of the Canadian Pacific railway will be first developed. The most promising of these exposures is one observed between Rat Portage and Rossland, where a highly colored, granitic rock of good quality affords exceptional facilities for quarrying and shipment, the line of the railway crossing the bare, level surface of tho granite. In a city of the energy and ambition of Winnipeg there should be a moderate demand for granite, and with the growing towns to the west of it a very fair market might be established for this beautiful, ornamental and monumental stone.

Slate.

Gibbons' quarry.

There is excellent roofing material in the slope of clay-slate on the Lake of the Woods, which will undoubltedly in time find a steady market in the enormous amount of building that will be the necessary concomitant of the development of the North-west. An enterprising effort has already been made towards the establishment of a slate-quarrying industry. In 1884 Mr. Gibbons opened a slate-quarry on an island lying to the west of Pipe-stone Point, and during the greater portion of the summer of that year had a gang of ten men engaged in taking out slate for the Winnipeg market. The work was not continued in 1885. The slate here quarried is not, however, the best that is to be found on the Lake. It is an evenly cleaving, soft, dark to glossy hydromicaceous schist, which presents unusually good facilities for quarrying due to the jointing which cuts across the planes of cleavage at definite intervals. The slate is readily cut or pierced by the slate-axe, taking an even edge, and not shattering when struck. It makes a fairly good roofing slate, but it is desirable, if the slate-quarrying industry is to be put upon a permanent footing, that the regular blue-black, slaty argilite, which is in general use by builders elsewhere, and which is found at several points in the lake, particularly in the neighborhood of Yellow Girl Point, should be worked first, as having the best chance of succeeding. Some of this slate from a small island north of Yellow Girl Point, was found on submitting it to rough tests to be remarkably non-absorbant, even in surface specimens.

Tests to be applied to slate.

Prospectors in looking for slate quarrying locations on the lake are often at a loss to know when they really have a good slate or not. The following few simple rules, familiar to those in the trade, will enable them to distinguish a bad slate from a good one with sufficient certainty to be useful :—

(1) As a rule, good slate when struck gives a clear, bell-like sound.

(2) It is generally considered a good sign when it shatters more or less before the edge of the axe.

(3) Light-blue slate is less absorbent, as a rule, than black-blue varities.

(4) Good slate has a hard, rough feel, while an absorbant slate feels smooth and greasy.

(5) The absorptive powers of a slate may be tested in two ways. (1) Place the slate on edge half immersed in water. If it draws up the water and becomes wet at the top in six or eight hours, it is spongy and bad. The extent to which the water ascends is roughly the measure of absorption. (2) Weigh a piece of the slate dry and then again after immersion in water for twelve hours, after wiping off the superficial moisture; if it shows much increase in weight it is too absorptive to be good.

The better qualities of slaty argillite do not occur extensively on the Lake of the Woods, but on part of the shore of Shore Island, and one to two and a half miles north-east of Yellow Girl, it occurs in sufficient abundance to be of considerable economic interest.

Talc, Soapstone, Potstone, &c.

Talc.

Pure talc, of pearly, whitish-green, foliated aspect, occurs in small, segregations in some of the softer green schists, of the islands of the lake, and some handsome specimens have been brought into Rat Portage, said to be from an island two miles south of the town. Although this pure talc is sometimes ground and used as a lubricant or polisher, it is doubtful if it occurs in sufficient quantities on the Lake of the Woods to be of economic value. The less pure, grey-coloured granular variety of talc, known as soapstone, or steatite, is, however, more abundant, and forms at least one extensive deposit which constitutes the rock on both sides of the canoe channel, one and three-quarter miles south-west of French Portage for a distance of a hundred yards or more. This place has long been resorted to by the Indians for material for their pipes. Tho rock is soft, sectile, and frequently free from grit, taking a moderately fine polish with ease, it presents excellent facilities for quarrying, and would require no intermediate transport from the quarry to the barges. It lies within a few hundred yards of the regular

Soapstone.

tug channel through the lake, and will doubtless be of considerable value as the nearest source of supply of furnace linings, fire-stones, slabs, &c., when those commodities come into demand in Manitoba and the west. Its most important use lies in its refactory nature, when subjected to intense heat. It has other uses, however. In its powdered state it may be used as a "mineral paint," or in the absence of graptite as a lubricant for heavy machinery. Other uses, of a minor character, would help to make its working profitable if the industry were once established. On the west end of Ptarmigan Bay, dark-green chlorite, apparently the pure mineral, occurs in irregular veins in the hornblende-schist, and may prove of some value.

A valuable refactory material for the manufacture of fire bricks is found in the felsites and felsite-schists which are abundant in various parts of the Huronian area.

Serpentine Asbestus, &c.

As is indicated on the map, serpentine occurs in a number of places on the Lake of the Woods and Shoal Lake, but the varieties observed are not such as would make attractive ornamental stones. It is not associated with limestone and has not the clouded or mottled aspect usually found in marble formed by the association of these minerals in the same rock mass. The serpentines is of a dark, olive-green color for the most part, of a granular texture, and strongly impregnated with magnetite. **Serpentine.**

In the masses of serpentine occurring on the shore to the south-west of Wiley Point, numerous small veins of chrysotile or picrolite (commonly called asbestus) occur, and more careful prospecting might possibly reveal larger, workable quantities of this valuable variety of the mineral serpentine. True asbestus or fibrous hornblende is of general occurrence in the hornblende-schists of the Huronian area, particularly in small segregated bunches and along slickenslided surfaces. It was not observed to occur in quantities economically important. The most interesting localities are the rock sections between Winnipeg River and Rat Portage on the railway, Matheson's mica location at the south end of Falcon Island and on some of the Hades Islands. **Asbestus in inconsiderable quantity.**

Mica.

The pegmatite dykes which cut the schists and gneiss towards the southern portion of the lake give promise in places of affording a supply of mica in sheets sufficiently large to be of economic

Quarry at Falcon Island.

value. On the south side of Falcon Island two locations were taken up and first worked for mica in 1885. The rock exposure from which it is mined, or rather quarried, lies inland about a quarter of a mile north-west of the extreme south point of the island. At the time when I visited the location (June 30th, 1885) the pit was thirty-nine feet long, six to eight feet deep and about eight feet wide, cut across the whole width of a pegmatite dyke which seemed to strike in a north-west direction, although being covered for the most part, the strike is vague and uncertain. The dyke consists of orthoclase, chiefly in huge flesh-colored crystals, with some quartz and mica, which are intimately associated, and in the section appear to be segregated in irregular streaks, of a vein-like aspect, in a more or less vertical attitude. The mica, though in large crystals, bears a small ratio to the whole mass of the dyke. The mica taken out to that date was practically surface mineral, and it is not therefore a matter of surprise or disappointment that it should be rather clouded with films of iron oxide. A large proportion of it was quite good for the ordinary uses to which it is adapted and some of it had been proven to stand fire well by practical use in some of the coal stoves in Rat Portage during the previous winter. At depths farther removed from the weathering influences of the surface, clearer and less clouded crystals will very probably be found. Other mica "finds" have been reported from Sabaskong Bay and Big Island, as well as from Rainy Lake, but the location on Falcon Island is the only one that has been worked.

Hones and Whetstones.

Many of the felsites or micio-granites of the region are of sufficiently fine and compact texture to make good hones, and fragments of the more suitable varieties of mica-schist, which are in common use at Rat Portage and among the Indians, serve as excellent whet-stones.

Carbonaceous Schists.

Supposed graphite of no value.

Associated with the soft, fissile, hydromicaceous or magnesian schists of the lake there occur in several localities bands of jet black carbonaceous or sub-graphitic schists. These schists have a very characteristic vesicular structure and are strongly impregnated in most cases with pyrite. The present note is not for the purpose of calling attention to any economic value of these schists, but rather the reverse, viz., to point out their worthless character from an economic standpoint and so endeavour to save time and money to prospectors, who may be tempted to explore those bands in the belief that they have discovered

a graphite mine. As I have been consulted several times by prospectors at Rat Portage respecting the value of these carbonaceous schists, and as some seemed persuaded of their graphitic character, it may be useful to repeat that specimens from the band of carbonaceous schists that crops out on the shore, one mile south of the mouth of Ptarmigan Bay, examined in the laboratory of the Survey by Mr. Frank Adams, yielded only 5·773 per cent. of carbonaceous matter, after drying at 100° C; and another specimen lost 7·47 per cent. on ignition, nearly all, probably, carbonaceous. The opinion of Mr. W. F. Downs, chemist to the Joseph Dixon Crucible Co., Jersey City, is decisive as regards its commercial value. Half a dozen specimens from different localities were submitted to him, and speaking of the general character of the schist, he says:—"It is hardly plumbaginous, though certainly highly carbonaceous, and it lacks most of the distinguishing features of graphite. Its only possible economic value would be in the manufacture of cheap facings, but the ingredients of these are very cheap, so I see no value in it."

This does not preclude of course the possibility of discovering deposits of true graphite in the region.

Brick Clay.

Clay, suitable for the manufacture of bricks, is not plentiful in the northern portion of the lake or in the immediate vicinity of Rat Portage, a fact which is in harmony with the general paucity of the finer kinds of glacial drift in this portion of the region. The only locality where an attempt has been made in the direction of brick manufacture is at Fitzgerald's farm, about four miles south-west of Rat Portage, where, in the summer of 1884, some 50,000 bricks were made and placed upon the local market for chimney-building, &c. The brick thus turned out seemed to be somewhat arenaceous, but was strong and serviceable, and of a bright red colour. The demand has not apparently warranted the continuation of the manufacture, as I am not aware of any more brick having been burned up to date.

Apatite.

This valuable mineral, though common as a microscopic constituent of the massive rocks of the region, has not been found anywhere in deposits of economic value.